REGIONALIZATION OF SOLID WASTE DISPOSAL SERVICES:

A CASE STUDY IN SOUTHERN MANITOBA

by

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A Practicum Submitted
In Partial Fulfillment of the
Requirements for the Degree,
Master of Natural Resource Management

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Abstract

Previous to this study, very little attention had been given to the problems of solid waste disposal in rural Manitoba. As a result of legislation enacted in September1976, (Regulation 208/76), towns and municipalities in Manitoba are now required to upgrade their solid waste disposal facilities to a level specified in the regulation.

This study examines the economic, social, environmental and administrative problems encountered by rural Manitoba administrations in the provision of waste dispoal services. Some of the difficulties are consequences of the new standards required of disposal sites; rural administrations have neither the experience nor the information with which to formulate an economically and environmentally sound response to the legislation.

This study proposes a scheme of regionalization of solid waste disposal services as a means of resolving some of the problems now confronting town and municipal councils. The cost components of a regionalized landfill site serving a mean population of 13,500 are compared to the costs of operating a site serving only 5,000 persons.

The results of this comparison indicate that considerable economies of scale can be achieved for the larger, regionalized site. It is 1.3 times as costly on a per ton base for disposal of wastes in the smaller, single site. The results also indicate that on a per capita basis, the initial capital investment is twice as costly for the smaller site.

It is concluded that regionalization of solid waste disposal services can result in considerable economic, social and environmental benefits. It is also noted that certain political and administrative issues may impede attempts to implement a regionalized scheme.

ACKNOWLEDGEMENTS

Many persons, too numerous to thank individually here, gave me valuable advice and supplied useful information in the course of preparing this practicum. I wish particularly to thank the members of my practicum committee: Dr. Darryl Kraft, University of Manitoba; Mr. Norman Brandson, Department of Mines, Resources and Environmental Management; and Dr. Dennis Schulte, University of Manitoba.

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CHAPTER ONE

INTRODUCTION

1.1 General Problem Statement

Recent legislation, enacted in September of 1976, pertaining to solid waste disposal in the province of Manitoba, has created a critical situation for rural municipalities and towns. These administrations have been given two years from the date of enactment to comply with the legislation. Operating conditions stipulated under the new regulations require the upgrading of approximately five hundred landfill operations scattered throughout the province. For example, disposal sites serving populations of 5,000 or more are required to upgrade their operations to the level of a sanitary landfill (i.e. soil cover must be applied daily), a requirement which serves to illustrate how severe the legislation is.

The new legislation reflects the trend of the past decade toward environmentally conscious practices in terms of resource utilization. With the change in consumer orientation to a "throwaway society" the problem of what to do with garbage has increased phenomenally. Both population and generation of waste per capita have increased but the policy instruments that deal with these problems have lagged behind.

Rural municipalities and towns in Manitoba did not anticipate such a sudden change in solid waste management policy. Previous to this study, very little attention had been given to the problems of solid waste in rural Manitoba; consequently, rural municipalities and towns have neither the experience nor the information with which they can formulate a response to the recent legislation. More important, perhaps, is the fact that the new legislation requires an immediate and considerable capital outlay on the part of the local administrations.

In 1971, a number of rural administrations in Southern Manitoba approached the provincial government for help in developing a scheme that would enable them to share resources[1] and thus reduce costs in the provision of waste disposal service to their residents. This study is an indirect result of that initial overture. In light of recent legislative developments, the desirability of examining various co-operative schemes for waste disposal is great.

This study develops a framework of analysis of general applicability for the implementation of a regionalized solid waste management system. The specific area under consideration includes the four Rural Municipalities of Rhineland, Morris, Montcalm and Stanley and the incorporated towns and villages within. The selection of this area was based on recommendations from provincial government officials who felt that this area showed the greatest potential of overcoming administrative and social problems in the implementation of a regional plan.

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1 Both capital and material resources are referred to in this statement.

This study necessarily includes an examination of collection services in the study area.[2] A regionalized plan for disposal services would reduce the number of local waste disposal sites presently in existence in favour of one large site. A basic assumption of this study is that the level of service[3] to residents will not be appreciably reduced from that which is presently enjoyed. Improved collection services which serve to replace the existing local "dumps" will ensure that this assumption stands; for this reason, several collection alternatives are considered.

As has been stated, options include many forms of collection services which merely serve to replace the existing facilities. The other systems available would improve the level of service available to residents, e.g. house-to-house collection in rural towns which do not presently have collection. Given the 10-year time horizon which is assumed on this study, there is some possibility that these alternatives will be implemented; this supposition is supported by the acceptance of

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2 Collection services will be discussed in Volume II of this study.

3 In this particular case, "level of service" refers to the distance each resident has to travel in order to dispose of his solid wastes.

such alternatives in rural areas of Ontario and the United States.[4] It is not unforeseeable that rural Manitobans too, will demand improved collection services.

1.2 The Study - A Perspective

The procedure of cost-minimization for a solid waste disposal and collection system is primarily concerned with the designation of a cost-optimal service area. The two principal economic determinants of an optimally sized area are the transportation costs and the landfill costs. Transportation costs per unit of waste hauled, i.e. ton-miles, inevitably increase with an increased service area, i.e. square miles. It is a well documented fact, however, that landfill costs achieve significant economies of scale with increases in the volume of wastes processed each year. Brown and Lebeck[5] have carried out an analysis of a rural situation in New Mexico; their findings indicate that both initial and annual operating costs do not change significantly over small landfill operations, i.e. wastes generated by populations of less than 8,000 people. This results in an extremely high unit cost for the smaller waste flows.

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4 Brown, F. Lee and Lebeck, A.O. Car, Cans and Dumps: Solutions for Rural Residuals. Resources for the Future. John Hopkins University Press, 1976.

5 Ibid.

In order to determine the component costs for varying sizes of landfill operations in the study area, two scenarios have been devised, each incorporating a different scale of operation within a test area.[6] Each scenario covers a 10-year operating period from year 1 (1976) to year 10 (1985) inclusive. Scenario 2 describes the situation as it presently exists in the study area, (i.e. three landfill sites: towns of Morden and Winkler and the Rural Municipality (R.M.) of Stanley operating independently with no co-operation among the two towns and the rural municipality.) Scenario 2 assumes that all three sites are operating in accordance with the regulations stipulated in the September, 1976 amendment to the Clean Environment Act. This assumption hastens the time when the regulations must actually be complied with from September, 1978 to September, 1976.[7]

Scenario 1 describes a situation where there is full co-operation between Morden, Winkler and the R.M. of Stanley in provision of waste disposal facilities and services. "Full co-operation" is taken to mean sharing of administrative, capital and operating costs for one regionalized landfill site which would accommodate the solid wastes generated by the residents of Morden, Winkler and the R.M. of Stanley. Total costs would be prorated on a population basis.

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6 A test area was designated because the researcher found the study area too large an area to examine in detail given the time constraints of this study; the area decided upon was the R.M. of Stanley and the towns of Morden and Winkler.

7 The amendment stipulates that local administrations have two years from the date of enactment to comply with the regulations; i.e. they have until September, 1978.

1.3 Research Objectives

In light of the preceding discussion, the objectives of this study can be stated as follows:

a) to examine administrative, social, policy and environmental issues related to:

- present solid waste operations in the study area (i.e. Scenario 2)
- the hypothetical case of a regionalized system (i.e. Scenario 1).

b) to develop a framework of general applicability for evaluating the potential of regionalizing solid waste disposal services in rural Manitoba below the 53^{o} parallel,[8] against economic, social, political, and administrative constraints.

- this will involve a comparison of two scales of waste disposal operations in a specified test area, in terms of the degree of cost efficiency which can be achieved by each.

1.4 Definition of Terms

a. solid waste: in this study, will refer to the unwanted products of domestic, commercial and industrial processes. Although solid wastes can be either organic or non-organic, wet or dry, they do not include sewage wastes.

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8 Disposal methods used in perma-frost regions differ from the landfill method described in this study.

b. garbage: strictly used, this term refers only to wastes from preparation, cooking and serving of food; market wastes; wastes from handling, storage and sale of produce.

c. rubbish: includes combustibles such as paper wastes, tree branches, yard trimmings, and non-combustibles including metals, tin cans, glass and crockery.

d. waste management system: broken down into 4 major functions or unit processes: storage (i.e. at place of origin in bins, bags, etc.), collection, transportation and processing.

e. solid waste disposal system: in this study refers to the last two processes involved in a solid waste management system.

f. disposal site/facility: in this study will refer to the ultimate deposition site for the solid waste; the facility referred to is assumed to be some form of a landfill.

g. sanitary landfill operation: describes a system where wastes are disposed of by spreading them in thin layers, compacting them to the smallest practical volume and covering them with earth each day in a manner that minimizes environmental pollution.

h. landfill site: in this study, refers to disposal operations which do not conform to the description of a sanitary landfill site. Thus, this category includes a diverse collection of sites ranging from open dumps where indiscriminate dumping and burning are regularly practiced, to those sites which are now more closely regulated (e.g. where cover may be applied once/month, or twice/year, etc.).

i. study area: refers to the R.M.s of Morris, Montcalm, Rhineland and Stanley and the incorporated towns and villages within.

j. test area: refers to the R.M. of Stanley and the towns of Morden and Winkler.

1.5 Delimitations

Although a great many systems and techniques are available for processes associated with waste management, this study will not attempt to evaluate the effectiveness of various alternative systems of waste management (i.e. systems other than the sanitary landfill method). No comparison of the effectiveness of the present system with alternate systems will be made.

No attempt is made to empirically assess the damages inflicted on the social, biological or economic sectors of the environment by the solid wastes.

No attempt has been made to predict future changes in policy regarding solid waste disposal in Manitoba.

1.6 Description of the Test Area

a. Geographic

The boundary of the test area extends from Range 4W to Range 6W inclusive and from Township 3 to Township 1 inclusive. It covers an area of 324 square miles and is bound on the south by the international boundary.

The area is well provided with a road and rail network which converges upon Winnipeg (Fig. 1). An improved earth or all-weather road surrounds most sections. The area is traversed from east to west by provincial highways 3 and 14 and from north to south by highways 3 and 22. The Canadian Pacific Railway crosses the area passing through Morden and Winkler.[9]

There are three landfill sites in the test area:

- Town of Morden landfill located on S 11, TP 3, R6W
- Town of Winkler landfill located on S 3, TP 3, R4W
- R.M. of Stanley landfill located on S16, TP 1, R5W.

b. Population

According to the 1976 census, the test area has a population of approximately 12,000. This represents a population density of 37

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9 Smith, R.E. and W. Michalyna. Soils of the Morden-Winkler Area. Manitoba Soil Survey Report No. 18. Manitoba Department of Agriculture, 1973.

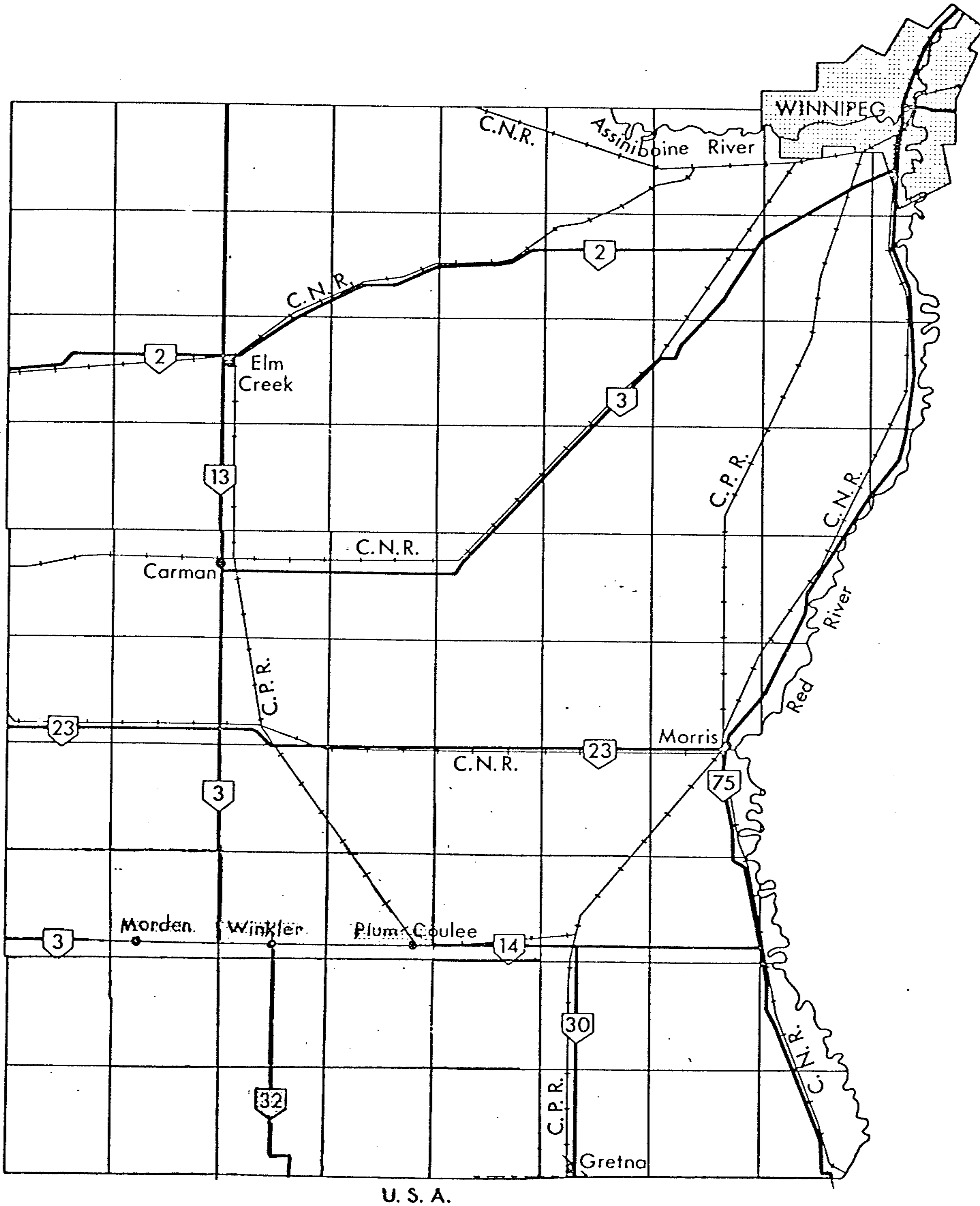

FIGURE 1

Towns, Villages and Main Transportation Routes located in the Morden-Winkler Area in relation to Winnipeg.

Source: Smith and Michalyna, Soils of the Morden-Winkler Area. Manitoba Soil Survey, Soils Report No. 18, Manitoba Department of Agriculture, 1973.

persons per square mile; however, 62.3 percent of the population is concentrated in the towns of Morden and Winkler and approximately 15 percent live in unincorporated villages.

c. Social/Cultural/Economic

The test area is part of a block of land west of the Red River and the International Boundary toward the Pembina hills, which was settled by Mennonites in the latter part of the 19th century. Today, Morden and Winkler are important rural business and cultural centres for Mennonite and Anglo-Saxon groups.

The area is primarily agriculturally based.[10] Locally grown legume crops are processed at canning plants in Morden and Winkler but much of the agricultural produce is marketed outside the area. Sugar beets are grown under contract from the Manitoba Sugar Company in Winnipeg, 80 miles northeast of the area. Sunflowers are processed in Altona just east of the test area. Dairies are located in Morden and Winkler and there is a poultry processing operation at Morden.

d. Geological/Hydrological

The test area geology is characterized by Precambrian rock overlain by deposits of paleozoic and mesozoic age.[11] Along the face of the Manitoba Escarpment which borders the west side of the test area, there are outcrops of the Vermillion River formation. Overlying the bedrock is glacial till deposited during the Pleistocene era. This

10 The author has drawn freely from Smith, R.E., et al. p. 2

11 Smith et. al. p. 5

till varies in thickness from a few feet to as much as 240 feet where it was deposited in a preglacial valley running through Winkler and Roland. The average thickness is between 20 and 30 feet but varies from 5 to 20 feet along the Manitoba Escarpment. This till is composed of shale and clay mixed with stones and rock flour derived from granite and limestone rocks carried into the area by glaciers.

Lacustrine deposits of sandy textured material overlying clay, lie immediately adjacent to the Manitoba Escarpment. Erosion and stream action has carried clay material from the shaly area of the escarpment and deposited it as alluvial fans over the sandy material (see Fig. 2). The result is that the test area is extremely variable in terms of the composition of the overburden layer. There is also a large frequency of areas where interstratified lenses of porous sand or gravel are underlain by relatively impervious glacial clay. This situation results in isolated high zones of saturated material (otherwise termed "perched water").

A unique feature of the Morden-Winkler area is the occurance of the "Winkler Aquifer" which consists of up to 200 feet of sand and gravel deposits (see Fig. 2). The highest part of the aquifer is at or near land surface north of Deadhorse Creek some 4 miles northeast of Winkler and is covered by 30 to 40 feet of stratified silty clay to clay and till deposits near Winkler.[12]

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12 Smith et. al. p 54

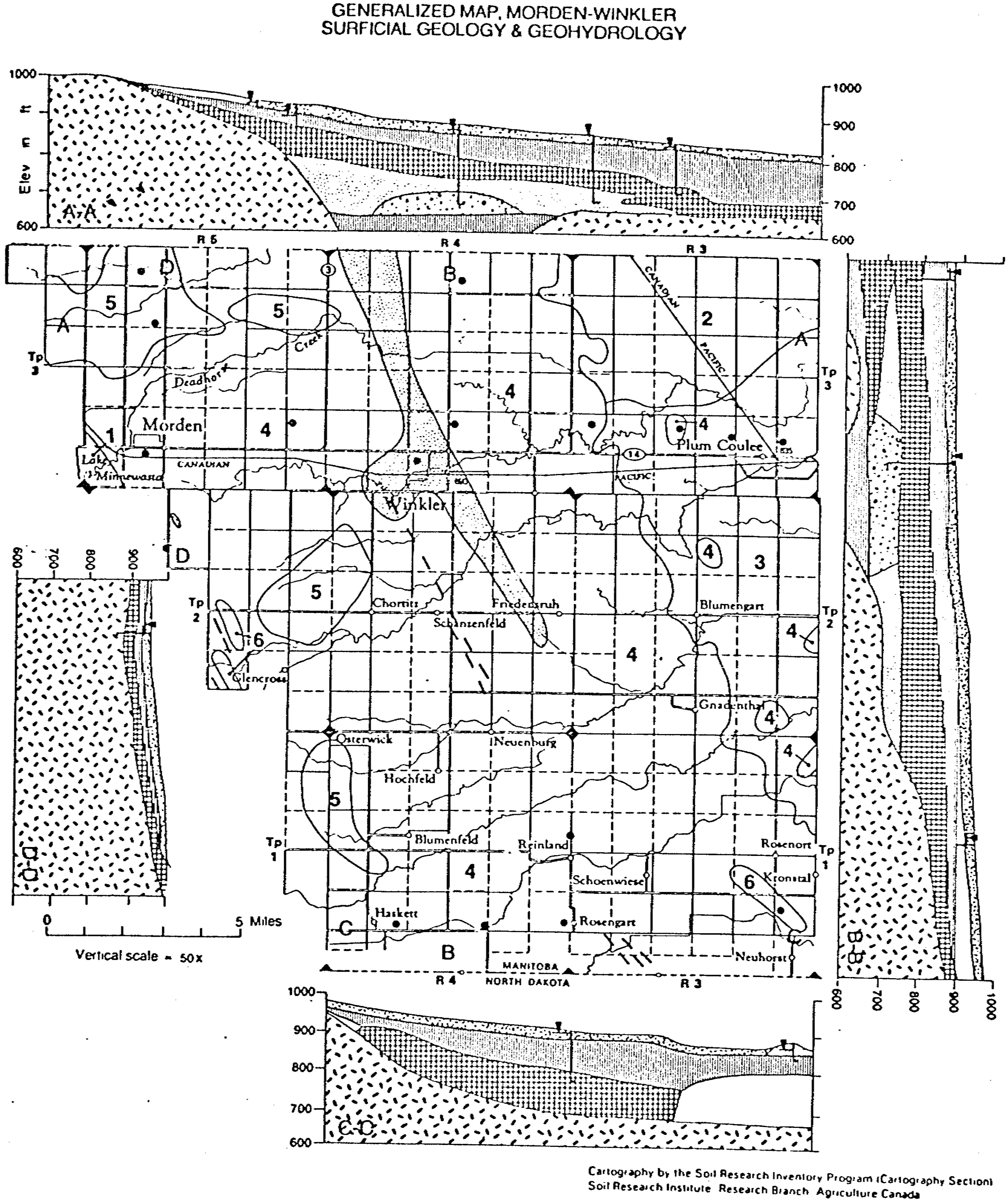

FIGURE 2

Generalized Map of the Morden-Winkler Area – Surficial Geology and Hydrogeology

CHAPTER TWO

SPECIFIC PROBLEMS DEFINED

A large proportion of time spent by the researcher in the study area was directed at coming to terms with exactly what the problems of rural waste management are. Some problems are immensely complex; for example, the issues surrounding regulations dealing with solid waste management practices. In addition, the reseacher encountered a myriad of lesser and more easily resolved problems. This chapter examines some of the implications of the general problem statement of chapter one in greater detail.

2.1 Policy and Regulations

2.1.1 The Public Health Act

Prior to the inception of the Clean Environment Commission and the bringing into force of the Clean Environment Act in 1970, legislative authority regarding the disposal of solid wastes in the province of Manitoba lay solely with the Department of Health and Public Welfare. Section 33 (17) of the Public Health Act (1965) empowered the Lieutenant Governor-in-Council to make any regulations respecting the location, construction, maintenance, cleansing and disinfection of waste disposal grounds, incinerators and other means of disposing of refuse and waste materials.

Pursuant to this, Manitoba Regulation 85/65, Section 48-5 6D, outlined specific requirements for the establishment and operation of waste disposal grounds. Section 53 of this regulation required that all waste disposal grounds:

- be served by an all-weather access road;
- be subject to the "regular" addition of cover material;
- have an "adequate" rodent and pest control program;
- have "adequate" identification and warning signs.

Open burning was prohibited; waste disposal grounds were to be located 100 yards from existing public highways or railways, and ¼ mile from any dwelling, school, habitable building or cemetery. No waste disposal ground was to be located where it could cause pollution to surface or groundwater sources of potable water. All requirements pertaining to waste disposal grounds were subject to the discretion of the medical officer of health.

The regulations governing the establishment and operation of waste disposal grounds were unamended in the Revised Regulation P210-R3, 1973, a regulation respecting sanitation under the Public Health Act. To date, regulation 85/65 has not been amended or repealed.

There were several problems with regulation 85/65 which were manifested in disposal grounds operated in an unsafe and unsanitary manner; i.e., no cover was applied, open burning and indiscriminate dumping were common, and rats and pests presented a health hazard. The problem is two-fold:

a) The wording of the legislation itself is nebulous and open to varying interpretations; open-ended words, such as "regular", "adequate" and "pollution", are ambiguous; the result was/is,varying standards of operation.

b) Regulation P210-R3 was/is enforced by the local Medical Officers of Health (M.O.H.) and the Public Health Inspectors. Theoretically, under the Public Health Act, the M.O.H., who is responsible to the Minsiter of Health, has the authority to apply to the courts for an order to close down a waste disposal ground or take other preventive measures. The health inspector, who reports to the Department of Mines, Resources and Environmetnal Management, can, in turn, bring to the attention of the M.O.H. those disposal grounds which are deemed unacceptable in some regard. This practice of closing a disposal ground for failure to comply with operating regulations rarely occurs, for it is unfeasible to close a 'dump' without making some contingency for an alternate site. The public health inspectors and the M.O.H. can, and in fact do, make suggestions and requests to municipal and town councils regarding specific operating practices but it is extremely difficult to ensure that such requests are complied with. In terms of specific, realistic powers of enforcement, the M.O.H. and the public health inspector are effectively stymied.

2.1.2 The Clean Environment Commission

In 1970, the Clean Environment Commission (C.E.C.) was established pursuant to the conditions stated in the Clean Environment Act (C.E.A.), R.S.M. 1970 (amended C62, S.M. 1970). The Department of Health was charged with the administration of the Act. Under Section II, the Clean Environment Commission had general supervision and control over all matters related to the prevention and control of contamination of the environment. In terms of regulations pertaining to solid wastes, the Act contained one vague reference: Section 19(1) (f) gave the Lieutenant Governor - in - Council the authority to make regulations "designating a body of water or soil for the purpose of deposit or disposal of contaminants authorized by the Commission." Pursuant to Sections 13-16 of the C.E.A., no person could discharge or deposit to the environment any waste or contaminant unless a valid licence was held; the C.E.C. had authority to issue licences, to investigate matters of contamination of the environment and to hold hearings in regard to existing or proposed operations. Waste disposal grounds would presumably come under the authority of those sections.

The Clean Environment Act, C130 of the Revised Statutes, amended C62, S.M. 1970, was repealed by the Clean Environment Act, S.M. 1972, C76 - Cap C130. Under the 'new' act, administration of the Act now lay with the Department of Mines, Resources and Environmental Management, instead of with the Department of Health. This was probably one of the most significant aspects of the Act.

The new Act contained other provisions as well, which served to clarify the powers of the Commission. It required that all existing and proposed operations that released or would release contaminants into the environment apply to the Commisison for a licence. If the discharge fell within limits prescribed by regulations and if no complaints about the operation, which would warrant a hearing, were received, a licence would be issued. Thus, under Section 14(4) of the Act, existing disposal grounds were required to be registered with the Department of Mines, Resources and Environmental Management.

Section 14(3) gave the Commission authority to prescribe limits where they did not already exist, regulations in force pertaining to the matter at hand. Because there were no specific regulations under the Clean Environment Act governing the operation of waste disposal grounds, the Commission would assess the operation and prescibe acceptable operating limits on an individual basis.

In theory, the method of regulating waste disposal grounds by using a system of licensing was sound; in practice, it did not work. Few municipalities or towns already operating waste disposal grounds applied for a licence under the terms of the Act. Only those 'problem' dumps, which were considered unacceptable in some way, either by the Public Health Inspector or by a letter of complaint from person(s) affected by the operation, were assessed. The ineffectiveness of the system can be illustrated by referring to the situation in the study area. Complaints were received concerning the disposal ground operated by the Village of Gretna and the Town of Winkler. Limits were prescribed by the Commission for the Gretna operation; the Winkler case was still pending at the time of new legislation in September, 1976, which removed the authority of the C.E.C. to assess waste disposal operations on an individual basis. Thus, out of a total of 9 disposal grounds in the study area, only 1 was actually managed pursuant to the Clean Environment Act.

2.1.3 The New Legislation

In Manitoba, the legislative response to problems created by solid wastes has been spurred on by a general increase in environmental awareness and more specifically, by an unfortunate tragedy involving an inadequately fenced disposal site. Thus, in September, 1976, Manitoba Regulation 208/76, being a regulation under the Clean Environment Act, respecting waste disposal grounds, was passed.[2] This was the first piece of legislation aimed specifically at solid waste disposal operations in Manitoba (other than the Public Health Act) and represented a definite step towards increased regulation of operations which have direct impact on the environment.

Under the regulation, municipalities and towns are not required to file a proposal or register as provided for in subsection (1) and (4) of Section 14 of the C.E.A. Operators of a new disposal ground are required to register with the Department of Mines, Resources and Environmental Management (D.M.R.E.M.) before

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2 Appendix A

September, 1977 and to comply with all aspects of the regulation by September, 1978.

The regulation categorizes waste disposal grounds on the basis of population served. Class I represents the highest standard of operation and applies to waste disposal grounds serving a population in excess of 5,000 persons. The regulation requires that Class I disposal grounds be operated at the level of a sanitary landfill; i.e., that daily deposits be compacted and covered according to stated specifications and that the disposal area be enclosed by a fence at least 1.8 m. in height. Liquid wastes cannot be disposed of in a Class I ground.[3] Operators of Class I disposal grounds are required (unless otherwise approved) to install gas monitoring probes, gas venting systems and groundwater monitoring wells at the site, in order to monitor and regulate the escape of gases and leachates from the site.

Class II grounds, serving populations greater than 1,000 persons but less than or equal to 5,000 persons, are required to cover waste on a monthly basis, again, according to strict specifications. A fence, 1.8 m or more in height must surround the disposal area. Liquid wastes may be disposed of in Class II grounds but only according to the specific requirements set out in the regulations.

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3 This presumably poses a problem for the Altona-Rhineland disposal ground which, under the Regulation, is classified as a Class I ground. The liquid wastes from the C.S.P. Foods Ltd. plant are presently disposed in the municipal ground.

Class III disposal grounds, serving populations less than or equal to 1,000 persons represent the lowest standard of operation. The regulation requires that Class III ground be subject to "a general clean-up at least once in the spring and once in the fall of each year or more frequently if required by the department" at which time the waste must be covered with at least 15 cm of earth. A fence of at least 1.2 m in height must contain the solid waste within a restricted area. Liquid wastes can be disposed of according to stated specifications.

All classes of waste disposal grounds must control rodent and insect populations. The regulations also specify allowable locations for a disposal ground in respect to dwellings, public roads and hydrological considerations, such as the location of the water table.

2.1.4 The "New" Planning Act

Choosing an appropriate site for a landfill site is a difficult task; although towns and municipalities may require expert help in making this decision, most administrations interviewed in the study area expressed a reluctance to approach the appropriate provincial government departments, which are able to offer help. The reason for this is that rural municipalities are currently experiencing what they feel is a transition of power; responsibilities for rural development and planning are increasingly being transferred from the municipalities to the provincial government. The new

Manitoba Planning Act, enacted January, 1976, is the policy instrument which is dictating this alleged change.

The emphasis in the new act is upon land use policy planning; the Act was drawn up to provide great flexibility for planning at the local level while still retaining provincial responsibility and authority at the policy level.[4]

More important, from the stand-point of this study, is that the Act actively encourages municipalities to resolve land use issues on a co-operative basis. To this end, the Act proposes the formation of planning districts where there is a commonality of interest. This point is elaborated upon in the following passage:[4]

> "But the Act also recognizes that effective planning can't take place when municipalities plan in isolation from their surroundings. Planning problems are not confined to jurisdictional boundaries, and solutions cannot be found without co-operative approach. When you analyze it, resource based conflicts have never been confined to man-made boundaries. Breezes blow, waters flow above and below the ground, wildlife wanders. Nobody ever told them about the municipal boundaries ......Therefore, it is impossible to plan alone. Recalling some of the examples of conflict between municipalities, we can see how planning on a larger than municipal or district basis could ameliorate the conflicts to some extent."

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4 Rural Land Use Conflicts: Some Solutions, Study 8, Manitoba Environmental Council. Chairman: William Bell. May, 1977

2.2 Economic/Social/Environmental Costs: The Unique Rural Problem

Although there is no scarcity of literature dealing with solid waste handling, the majority of it deals with specific incidents in American, urban settings. While some of this information is of general applicability, research results designed for urban solid waste management systems do not, as a rule, apply to rural problems. There are three important characteristics which differentiate the two systems:[5]

a. Much greater volumes of waste generated in urban areas, result in significant increasing economies of scale.[6]

b. Rural waste generating sources are widely dispersed over a low population density area and the cost factor related to transporting wastes to an ultimate disposal site becomes highly significant; this is in direct contract to urban situations.

c. Because of the problems of high volumes of waste produced by a concentrated population, urban centres are forced to consider the problem of disposal seriously; such centres usually have the resources to handle their wastes. e.g. full time managers, specialized equipment.

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5 Brown and Lebeck.

6 In this study , estimated waste loads were found to be of such low volume, that most published costs curves and other available cost information pertaining to waste disposal are not applicable. The exception is the information pertaining to the rural, low volume situation described by Brown and Lebeck.

There are other factors which serve to illustrate the uniqueness of rural problems of waste handling. Peoples' sensibilities are troubled by the marring of a rural, natural, environment. In other words, the marginal aesthetic damages imposed by an increment of solid waste is greater than that imposed by the same increment in an urban setting, where because of the vast amounts of refuse, the point of diminishing marginal damages has been reached.

The disposal of solid wastes often imposes damages on persons not directly involved in the disposal. Individuals adversely affected by the disposal experience external costs in many different forms; these externalities may be the spillover effects of both planned and unplanned disposal sites.

External costs fall into three categories:

a. Real money costs accruing to taxpayers due to the necessity of rectifying the adverse environmental effects caused by pollutants from a waste disposal site. For example, increased treatment necessary for potable water sources polluted by leachates from a disposal site or the costs related to the health hazard created by disease vectors such as rats and insects attracted to open dumps.

b. Social costs - this category of costs includes aesthetic and recreational degradation resulting from an open dump; more important perhaps is the alleged depreciating effect on prices in land in proximity to disposal sites. Although this effect has never been quantatively determined (in Manitoba), the fact remains that there are many bad connotations associated with a garbage dump; people do not want to live near a aump because of tangible annoyances, such as ordour, smoke and blowing litter.[7] People are even disturbed by the thought of residing near a "well-run" sanitary landfill site. This attitude was prevalent in persons interviewed in the study area by the reseacher.

Social costs are not readily quantifiable because the degree of damage perceived by an individual is subjective and other than for recreational uses, there is no market for aesthetic qualities. It is this category of costs, however, which is most often associated withthe problems of dispersed solid wastes in rural areas.[8] Because only a small proportion of the population actually confront these problems on a regular basis, the problem is often considered less severe in rural areas than in urban areas, in terms of aggregate quantitative damage proportional to the population damaged. In addition, since it is usually area residents who create the solid waste pollution, it is sometimes assumed by government authorities that area residents do not place significant value on the prevention of aesthetic damages.[9]

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7 Persons living close to a disposal ground, who were interviewed, expressed their dissatisfaction; for example, farmers within 5 miles of the Rhineland - Altona disposal ground were bothered by large infestations of rats which bred at the dump and migrated to farm buildings. Farmers owning land adjacent to the Stanley dump were annoyed with litter which was blown into their fields and presented a hazard to farm implements working the field. Other similar cases are documented in Appendix B.

8 Brown and Lebeck. p. 5

9 Ibid.

c. Environmental costs[10] - it is difficult and perhaps redundant to separate this category of costs from real money or social costs; however, some of the adverse effects of pollutants may not be manifested as immediate real money or social costs. Such would be the case in situations where the release of relatively small increments of pollutants to the environment may have a cumulative long-term detrimental effect; e.g. the long-term effects on the groundwater regime resulting from disposal of pesticide containers in municipal dumps.[11]

Appendix B lists those environmentally unacceptable situations in the study area which were directly observed by the author. Figures 3-12 depict actual sites in the study area; some operating problems such as blowing litter and indiscriminate burning and dumping are apparent from these photographs. In some cases, a relatively small expenditure would result in elimination of the more obvious problems. For example, indiscriminate dumping because of unsupervised public access to the site at all times could be rectified by a fence and a gate with posted dumping hours. Other problems require a larger capital outlay, -- for example, situations where the surface water regime is endangered by leachates from a disposal site. Unfortunately, there is little documented evidence pertaining to the present status of operations in the study area, in regard to environmental impact. Prior to September,

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10 The detrimental environmental effects of poorly run landfill sites have been well documented elsewhere; this study does not

Figure 3. The Morden landfill site.

Figure 4. Empty pesticide containers at the Plum Coulee site.

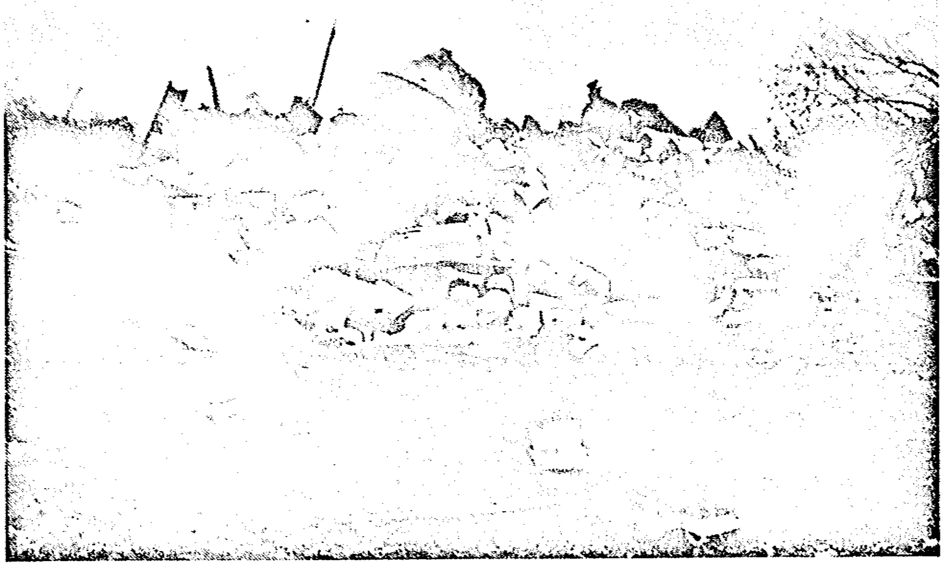
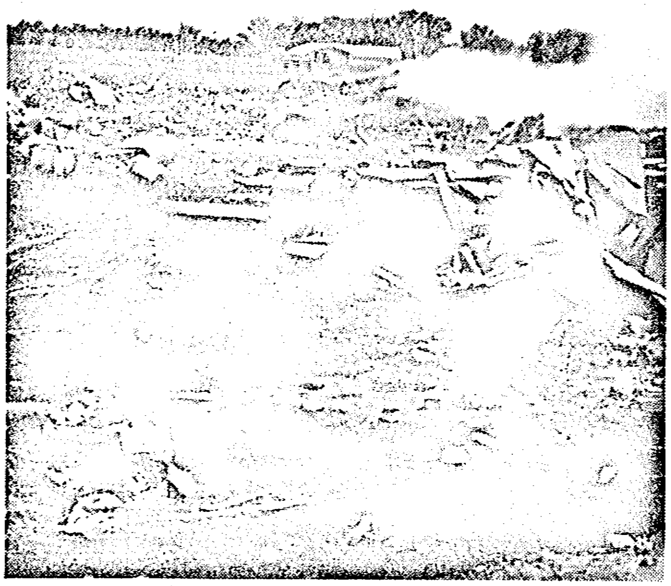


Figure 5. The R.M. of Stanley landfill site.

Figure 6. Refuse is pushed into a ravine at the R.M. of Stanley site.

Figure 7. Open burning at the Winkler landfill site; this site is located close to residences.



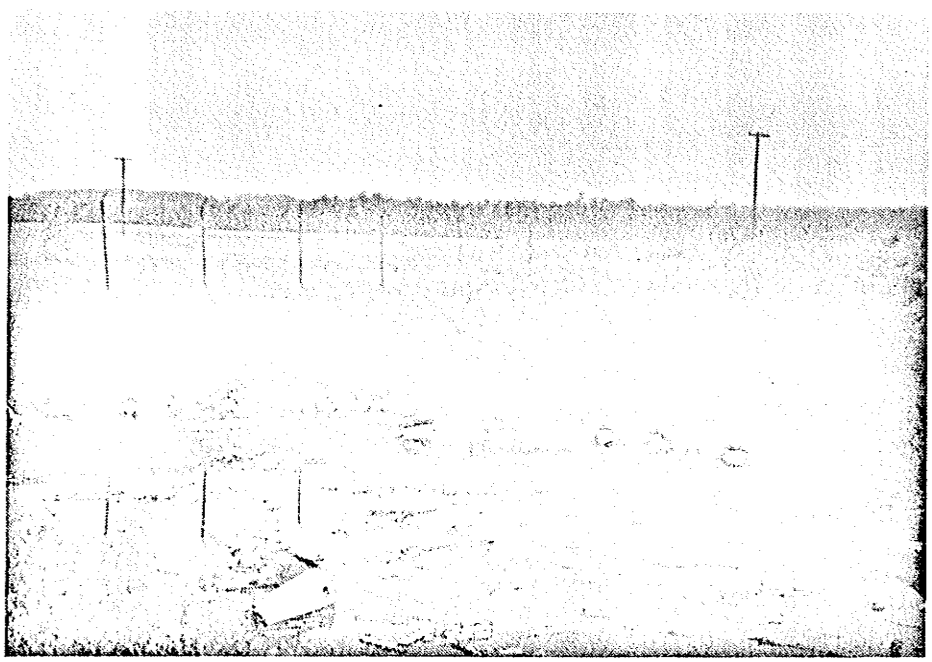


Figure 8. Flooded open pit at the Morden disposal ground.

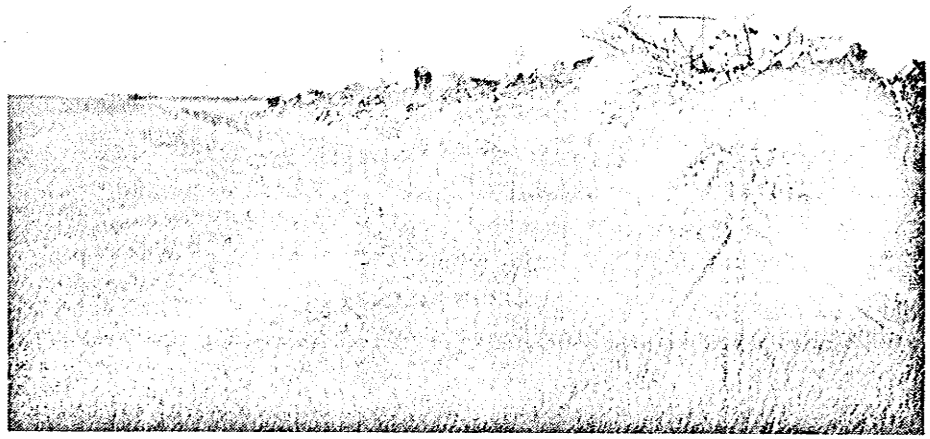


Figure 9. The Plum Coulee disposal ground is full to overflowing.

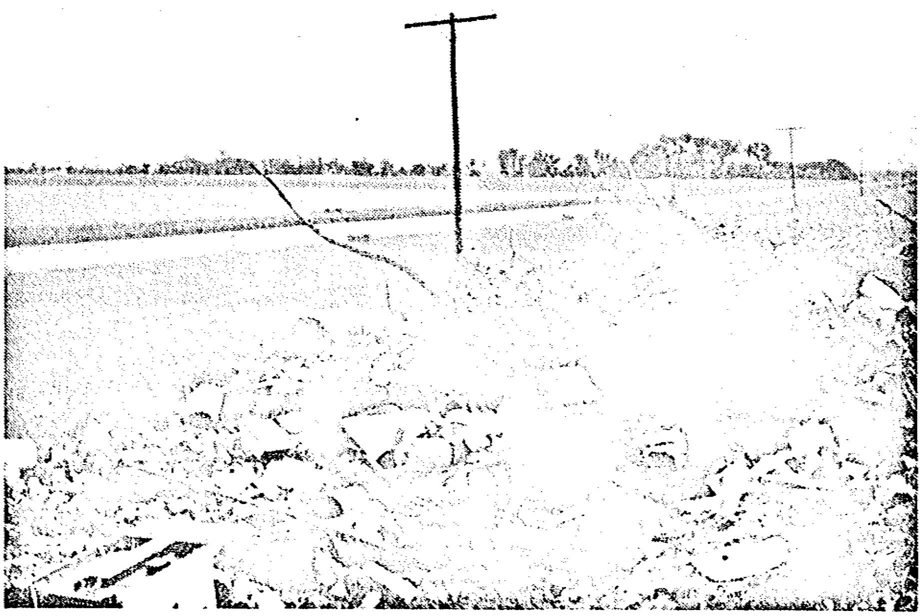


Figure 10. The Plum Coulee landfill site.

Figure 11. Refuse is blown onto a neighbouring farmer's field at the R.M. of Stanley disposal ground.

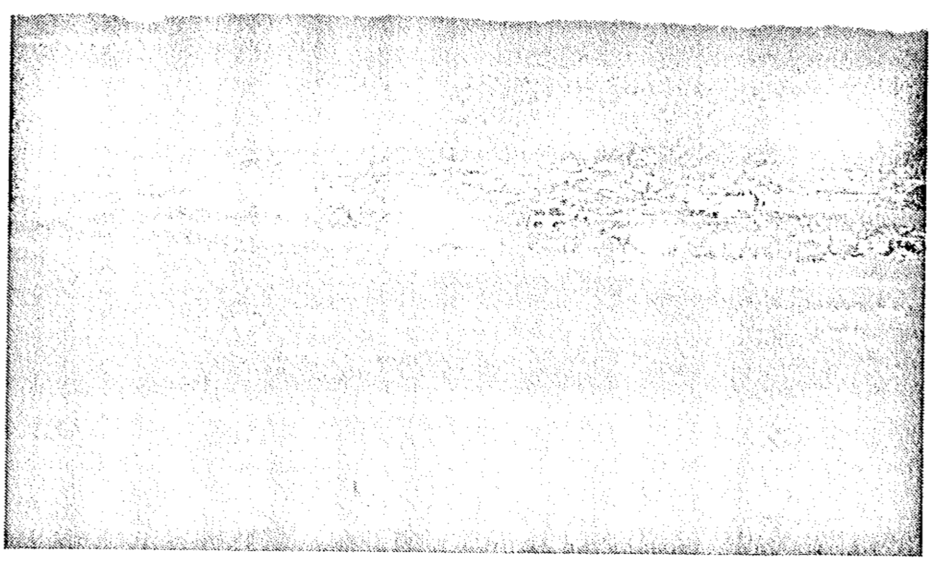


Figure 12. The R.M. of Stanley waste disposal ground.

1976, the only environmental assessments of waste disposal grounds in Manitoba were carried out under the authority of the C.E.C. -- only one site was assessed in the study area itself.

2.3 A Problem of Economics

The method of regulating waste disposal grounds in Manitoba prior to September, 1976, has been discussed in Section 2.1 This section examines some of the reasons why this system of regulations was not satisfactory.

Under the 'old' legislation, it was administratively very difficult to ensure that existing waste disposal operations applied to the Clean Environment Commission for a licence; the Commission operates as a regulating body and has really no administrative or enforcement function. For this reason, it did not/ does not have the resources with which to ensure full co-operation by the municipalities and towns in regard to the regulations set forth in the C.E.A. In other words, once made aware of the policy toward waste disposal grounds, it was up to the discretion of municipal and town officials to comply with the terms of the Act. The result, of course, was that local authorities within the study area, wishing to preserve the status quo and thus keep to an absolute minimum, costs of operating the dump, did not apply to

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deal with this aspect of waste disposal, other than in relation to policy and economic areas of concern.

11 The environmental effects of this practice have not been determined in Manitoba; the author is merely using this concept to illustrate a general idea.

the Commission for a licence. There is provision in the C.E.A. for enforcing compliance with the terms of the Act through a system of financial penalties; a town or municipality, if found to be errant pursuant to the C.E.A., can be fined according to specifications contained in the C.E.A. However, the unpleasant recourse to legal action is rarely exercised against town and municipal administrations.

Because the Commission is not able to solicit the co-operation of towns and municipalities, it was in the position of assessing and setting limits only for those disposal grounds brought to its attention either by the public health inspectors or by a general letter of complaint. The public health inspectors are in the unenviable position of having the responsibility of reporting errant councils to the Commission, who can then, pursuant to Section 14(10) and 14(11), order a town or municipality to "abate, control or cease" contamination of the environment. The problems of simple economics remain however: the treatment and disposal of solid wastes continues to be a low priority issue to rural residents relative to more serious economic and agriculturally related environmental problems with which they must cope.

In the past, most rural residents in Manitoba (with the exception of those centres with collection services) have handled the disposal of wastes on an individual basis. Any legislated or otherwise enforced change in this practice, especially a change entailing individual expenditures, is not favourably received.

Most rural residents interviewed in this study [12], with the exception of those living in close proximity to a dump (the distance varied with the standard of operation of the dump) expressed satisfaction with the existing system.

Local councils will not commit funds for purposes of upgrading disposal services unless pressure is brought to bear upon them. This pressure can come from two sources: if rate payers demand a higher level of service (and are presumably willing to have this reflected in their mill rate) councils are 'duty-bound' to comply. If Provincial authorities require affirmative action on the part of local councils, it would be necessary to ensure compliance by exercising some type of enforcement or incentive system. It should perhaps be emphasized that the 'do-nothing' attitude of local councils is not necessarily an irresponsible one; the policies of the local councils must reflect the wishes of the ratepayers.

Improved waste disposal services are not viewed as necessary by most rural residents -- if most residents need only come in contact with the local dumps on those occasions when they dispose of unburnable waste loads, then residents will not worry unduly about such problems included under the heading "Social/Economic/ Environmental Costs."

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12 Interviewing was carried out on a random, ad hoc basis in order to obtain a general impression about rural attitudes toward waste disposal problems; because interviewing was used as a general problem-sensing tool and because no quantifiable results were obtained, no statistical information is presented on the interviewing portion of the study.

2.4 The Effect of Regulation 208/76 on Existing Operations

2.4.1 An Economic Effect

Regulation 208/76 stipulates that operators of Class I disposal grounds will will required to provide equipment and an operator on a daily basis for purposes of compacting and covering wastes daily. In most cases, this requirement will mean locating a machine at the disposal ground on a permanent basis. Depending upon the quantity of waste handled each day, a machine operator may be assigned to the site on a full-time basis; alternatively, if only 2 - 3 hours of work are required daily, a town or municipal employee may be assigned the task as part of a roster of miscellaneous duties.

The regulation also requires Class I disposal ground operators to erect a 1.8m fence, to construct a berm surrounding the disposal area and to install gas and leachate monitoring equipment. Capital costs for upgrading a disposal site are examined in Chapter Four. At this point, suffice it to say that for an 'average' town of between 5,000 and 10,000 persons, in Manitoba, meeting these costs will require that the proportion of the annual town/municipal budgets assigned to waste disposal services be significantly increased.[13]

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[13] To give some idea of the money spent on maintaining a disposal system: in 1976 Altona's share of maintaining their Class I ground, shared on an equal basis with the R.M. of Rhineland, from Jan. 1976 - May, 1976, was $887.30. Altona's operation and maintenance costs are subsidized to the amount of 1 mill ($5,000.00) from the general tax levy.

Class II and Class III disposal grounds are not required to meet the high standards of Class I grounds in terms of compacting and covering wastes. They must, however, meet expenses stemming from: a) fence construction, b) berm construction, c) insect and rodent control programs, d) construction of liquid waste disposal facility (where applicable). Cost estimates for those items are presented in Chapter Four.

In the case where it is necessary to relocate a site because of locational specifications of the regulation, the town/ municipality will incur costs related to: a) closing down the old site, b) buying land for a new site, c) startup costs of a new site.

2.4.2. Securing a Site

Specifications regarding the location of waste disposal grounds will mean that some grounds may have to be relocated. For example, the Town of Winkler has been attempting to find land for a new site because the present grounds are located in close proximity to businesses, residences and a provincial highway. In addition, the ground is located in a saturated area where contamination by leachates to the groundwater is a definite possibility. The Village of Plum Coulee is even more desperate for a new site. Their disposal ground continues to be used despite the fact that the local Public Health Inspector has ordered it closed because it is full to overflowing. The local council has not been able to find a suitable piece of land at a price which they would be willing to pay.

Under the terms of Regulation 208/76, both the Plum Coulee and Winkler disposal sites would be required to relocate by September, 1978. These two examples, taken from the study area, are probably not isolated cases -- other towns and municipalities in Manitoba may find themselves in a similar position.

The problems of securing land suitable for waste disposal were mentioned by all of the town and municipal officials interviewed by the author. A parcel of land would be deemed completely suitable if:

i. it is located in close proximity to an all-weather, public, access road.[14]

ii. it is within economical transporting distance from the origin of waste production.

iii. it is <u>not</u> in close proximity to dwellings or businesses; towns and rural municipalities in Manitoba generally attempt to locate waste disposal grounds so that settlements are upwind from the site, relative to the prevailing wind direction.

iv. it is not located on prime agricultural land; ideally waste disposal grounds should be located on marginal land which is of course cheaper to buy. In addition, valuable land is not taken out of production.

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14 A right-of-way must be legally established - i.e., belong to the town or municipality or leased on a long-term basis. The R.M. of Stanley is presently experiencing problems related to an access route to the disposal ground which belongs to a local farmer.

v. hydrological and geological requirements are fulfilled; i.e. the base of the landfill is at least 1.5 m from the groundwater table, if runoff (from both seasonal and permanent channels) from upland surface waters is minimal, and if there is sufficient suitable soil cover available for on-site excavation.[15]

vi. it is not located so as to detract aesthetically or otherwise from a recreational area, natural area or a well-travelled route.[16]

vii. the price of the land (if the site is purchased) is 'reasonable'. In many instances, cited by officials interviewed, this constraint has proven to be insurmountable. Land owners are reluctant to sell their land to a town or municipality for purposes of waste disposal; this reluctance is manifested in the extremely high prices which are asked for even marginal agricultural land. For example, a parcel of land with a market value of about \$300/acre, may be sold to a town, which is desperate for a site, for as much as \$1,800/acre. The reason for this is two-fold:

- Farmers are reluctant to have a waste disposal ground located on or near their own property. They wish to avoid problems arising from odour, smoke and rats. In addition, a major problem observed by the author in the study area was garbage, blown from insufficiently fenced sites, cluttered neighbouring fields and proved hazardous to farm implements.

- Usually only a few acres are required for a site; this may result in fragmentation of a larger block of land and create problems for a farmer in terms of access to his own land.

For these reasons, local councils often find themselves in a non-bargaining position and must accept a selling price which is much higher than the actual value of the land.[17]

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15 Such criteria are discussed in Chapter 3.

16 A case in point is the Portage la Prairie disposal site, located directly off the Trans-Canada highway. This has resulted in aesthetic damage and in the creation of a public hazard when smoke from the site is blown onto the highway.

17 Plum Coulee and Winkler are currently experiencing difficulty in obtaining land at a 'reasonable' price.

The seven aforementioned criteria of a good site for a waste disposal ground can be divided into two main categories: those dealing with economic considerations and those which are primarily environmental in nature. It is very difficult to find a site which fulfills all seven criteria. Unfortunately, a trade-off is usually made in favour of the economic criteria and environmental considerations are largely ignored.

CHAPTER THREE

SANITARY LANDFILL TECHNOLOGY AND DESIGN

3.1 Site Selection

Site selection is perhaps the most important of the pre-optional steps in developing a satisfactory landfill operation. Many physical factors must be evaluated to determine suitability of a landfill site; some of these factors are discussed in the following sections.[1]

3.1.1 Landfill Space Requirements

a. Generation of Refuse

Knowledge of the amount of refuse generated is basic to the design and satisfactory operation of a waste disposal facility. There is much data related to per capita generation of solid wastes. Most of the literature based on American statistics[2] agrees that the United States national average generation rate is 5.32 lbs/capita/day (p.c.d.), consisting of about 3 p.c.d. from household sources, 1 p.c.d. from commercial sources, about 0.6 p.c.d. from industrial sources and about 0.2 p.c.d. from construction and demolition operations. These are approximate figures and refer only to material collected; they do not reflect the total amount of solid wastes generated.

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1 These factors do not include the social/economic criteria listed in Chapter 2.

2 Based on a OSWMP National survey in 1968.

Hagerty et. al.[3] gives approximate figures which are adjusted to represent the total wastes produced:

Source	Amount (p.c.d.)
domestic	4
municipal	1
commercial	2
industrial	2

Many criticisms have been levelled against the "official" Office of Solid Waste Management Programs (O.S.W.M.P.) statistics; the most serious criticism of the 1968 Survey is that it represented estimated, rather than measured (i.e. weighed), data. It has been suggested[4] that the survey returns and the estimates based on them, tended to overestimate collected municipal solid waste.

A survey of the private sector refuse collection industry by Applied Management Sciences Inc., (A.M.S.) in 1970, estimated U.S. per capita waste generation as 5.06 p.c.d. (for residential and commercial waste).

A survey carried out by the Resource Recovery Division of the Environmental Protection Agency in 1971 estimated waste flows from household and commercial industrial sectors; industrial and construction wastes, street sweepings, and sewage sludge were excluded (these categories were included in the 1968 survey). A per capita daily generation rate of 3.31 lbs. were decided upon.[5]

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3 Hagerty, Joseph D., Joseph T. Pavoni, and John E. Heer Jr. Solid Waste Management, Van Nostrand Reinhold Environmental Engineering Series, New York, 1973.

Canadian statistics dealing with waste generation are harder to acquire. In the Brown and Clark study on municipal waste disposal, generation rates were based on the city of Kingston, Ontario (population approximately 65,000). In 1969, the last year for which data is given, daily per capita generation for domestic, commercial, and municipal waste were 2.77, 2.97 and 5.74 lbs., respectively.

Statistics compiled for the Town of Winkler in January, 1976, indicate that, based on a 5-day collection week, just under 3 p.c.d. is generated. The Superintendent of Public Works estimated, in a letter to the Mayor and Council of Winkler, that this figure is expected to increase to 4 p.c.d. in the summer season.

This study assumes two different generation rates: a rate which reflects the urban (i.e. town) situation and a second rate which corresponds to estimates of rural waste generation. For the purposes of this study, an urban generation rate of 4 p.c.d. is assumed (for year 1, 1976). This rate is based on a 5-day collection week and a 260-day year. This figure would seem justified in view of the available data, most of which gives statistics only as recent as 1969. Wastes collected in the towns of Winkler and Morden are assumed to be comprised of domestic and commercial waste only.

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[4] Smith, Frank A. Comparative Estimates of Post-Consumer Solid Waste, O.S.W.M.P. U.S. Environmental Protection Agency, 1975

[5] Analysis of the results of these 3 surveys can be found in Smith, Frank A., 1975.

Fewer published statistics are available for solid wastes generated in rural areas. A 1968 American survey of community solid waste generation quotes a figure of 0.72 p.c.d. for domestic solid waste (collected on a daily basis) compared with 1.26 p.c.d. for the same category for urban areas.[6] It is not known what population density was used as a basis for differentiating "rural" from "urban" situations.

Brown and Lebeck[7] take 3 p.c.d. as a representative generation rate for their study of waste disposal problems in rural New Mexico. Their survey of 3 rural landfill sites serving populations of 700, 250, and 652, yielded a cumulative rate of 0.7, 4.3 and 3.0 p.c.d., respectively. The measured per capita accumulate in the 3 landfills varies greatly. Brown and Lebeck attribute this large variation to the degree of organization of the local practices for handling solid wastes. In regions with a commonly accepted community dumpsite, the higher figure for waste accumulation would apply; where community organization is lacking, the lower figure would be appropriate.

A rate of 30% the urban rate, or 1.2 p.c.d. (for year 1, 1976) is assumed to be a representative generation rate for rural areas in this study. Several factors contribute to this lower rate for rural areas. A survey carried out by the interviewer in the study area in 1976 found that most rural residents burned their paper refuse and recycled much of their household wastes as animal feed. Items, such as old

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6 American Public Works Association. Municipal Refuse Disposal. Public Works Administration Service. Interstate Printer and Publishers, Inc., Illinois. 1970

7 Brown and Lebeck. 1976

implements, tin cans and other inorganics such as rubber tires and pesticide cans were delivered to the local dump only when enough wastes to fill a half ton truck had been accumulated; thus, visits to the dump occurred on the average, once or twice a month. It should also be noted that the urban rate of 4 p.c.d. includes wastes generated by commercial outlets in the two towns; this component is absent in the case of rural waste generation. Estimates given by local municipal officials combined with available published statistics for rural situations have resulted in the assumption of a rural rate of 1.2 p.c.d. in this study.

In addition to the effectiveness of the waste collection system, waste generation is affected by prevailing social and economic conditions - two criteria which determine the amount of refuse produced, the amount salvaged, and in the case of centres with collection, the amount collected. Over the past decade, extensive use of canned and packaged frozen foods has caused per capita increase in the amount of "rubbish" produced while the quality of "garbage" has decreased because of more efficient food processing and better packaging. There is no reason to suspect that this trend will not continue.

Waste generation could logically be expected to follow the anticipated rise in per capita purchases of non-durable and durable goods during the next ten years. Hagerty et al[8] note that this represented an annual increase of approximately 4% for several years prior to 1973. According to the American Public Works Association[9] (A.P.W.A.) the American population has increased 30% since 1950, but the waste load has

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8 Hagerty et al 1973.

9 A.P.W.A. 1970.

increased 60% and is expected to rise by another 50% by 1980.

In terms of Canadian statistics Clark and Brown[10] have documented an 18% increase in daily per capita waste generation from 1965 to 1969.

Unlike other studies of a similar nature which do not make any allowance for increasing disposal rates, this study assumes an annual increase of 4% in the per capita generation rate for both urban and rural areas. This figure represents an anticipated increase due to:

- increased consumer purchases
- increased disposal packaging of consumer goods
- increases in the degree of organization of the solid waste disposal collection system in the study area.

b. Population

Population counts for the test area are based on the 1976 Census Preliminary Population Counts for the Province of Manitoha. An annual population increase of 2% is assumed from year 2 to year 10, inclusive. This figure is loosely based on percentage increases for Morden, Winkler and Stanley from 1965, 1971 and 1976 census data.

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10 Clark, R.H. and J.H. Brown. 1971

c. Density of the Waste

In order to relate the solid waste generated in terms of pounds per capita per day to the volume the waste will occupy in a trench, it is necessary to know the density of the in-place compacted refuse. Given this data on compaction and density, and given the data on refuse generation, the amount of land required for a fill and the length of time it can be used for disposal can be estimated fairly accurately.

The density of the compacted, in-place refuse has an effect on the amount of land required for the landfill site. This parameter has been the subject of many reports and much speculation. According to the A.P.W.A., few compaction tests have been made that are based on sound engineering practice. The in-fill density will depend, to a large extend, on the nature of the waste being disposed of. Where inorganic material such as construction or demolition wastes make up the bulk of the waste, densities greater than 800 lbs./yd/^{3} can be expected. Bulky, resilient materials such as paper wrappings, plastic or rubber will result in densities lower than this figure. Because refuse density varies largely with moisture content (increase in moisture content results in an increase in density), putrescible garbage will have higher in-place densities.

In-fill density also depends to a large extent on the type of equipment used to cover and/or compact the refuse and on the number of passes over the waste that are made. For instance, a larger, heavier machine will achieve higher densities than a lighter one.

Hagerty et. al[11] note that in order for the landfill to be economically competitive with other means of disposal, the compacted density of the refuse must be 800 lbs/yd^3 or more. The A.P.W.A. reports that a reasonably well-compacted sanitary landfill of shallow depth (less than 20 feet) should have an in-place density of 1,000 lbs./yd^3 or more.

Table 3-1 presents a summary of some reported density figures.

Table 3-1 In-Place Densities of Solid Wastes

Solid Waste Uncompacted Density (lbs/yd^3)	Density in Collection Vehicles (lbs/yd^3)	Density in Lanfill (lbs/yd^3)	Source
150	350-700	--	Demarco (1969)[12]
250 - 350	400-600	600-1400	Caterpillar Tractor Co. (1976)[13]
--	100-800+	1000-1250	A.P.W.A. (1970)[14]
250	500	750	Brown and Lebeck (1976)[15]
--	--	700-800	Clark and Brown (1971)[16]

11 Hagerty et al, 1973.

12 DeMarco, Jack et al., 1968. Incinerator Guidelines - 1969. U.S. Department of Health, Education and Welfare.

13 Caterpillar Tractor Co. 1976 Caterpillar Performance Handbook. 6th edition.

14 A.P.W.A., 1970.

15 Brown, F. Lee and A. O. Lebeck., 1976.

16 Clark, R.H. and J. H. Brown., 1971

In this study, an in-fill compacted density of 1,000 lbs/yd^3 is assumed; this is in keeping with the figures in Table 3-1. If the density of the mixed solid wastes delivered to the landfill in collection vehicles is assumed to approximate 250 lbs/yd^3, this in-fill density represents a compaction ratio of 1:4. It will therefore be necessary to provide at least (260 days) (4 lbs/day) $\div$ (1000 lbs/yd^3) = 1.04 yd^3/yr. of landfill space for an urban resident and (260 days) (1.2 lbs/day) $\div$ (1000 lbs/yd^3) = 0.39 yd^3/yr. for a rural resident (based on 1976 generation rates).

In this study, no allowance has been made for the effect on in-place density of differences in composition between rural and urban wastes. This is because rural wastes comprise only 10% of the total solid wastes generated.

d. Earth Cover

It is assumed that all the earth cover required for proper operation of landfill will be obtained from on site excavations. The present policy for Class I landfill sites requires that approximately one part earth to four parts refuse be applied as daily cover; i.e., every 2 feet of compacted refuse is to be covered with 0.5 feet of earth. Thus, for Class I landfills, a 20% space allowance is required for the accommodation of cover material.. A.P.W.A. notes however, that in actual practice, the allowance is closer to 5% because approximately 3/4 of the cover will shift into voids between refuse particles or become mixed in with the refuse in adjacent cells. For the purposes of this study, the regulation 20% allowance for cover is assumed; presumably this generous allocation will compensate for what may be considered the rather high compaction ratio which is assumed.

3.2 Design Factors

Much has been written about the elements of landfill design; it would be difficult and useless to repeat information here which has been well documented elsewhere.[17] Regulation 208/76 requires that all landfill sites in Manitoba incorporate certain specified elements of design. It is those factors (some of which are costed out in Chapter 4), which are discussed in this section.

3.2.1. Site Improvements

A proposed site for a landfill must be cleared of all trees, brush, and tall grass that could hinder landfill equipment vehicles. This clearing process should be done in incremental steps - as more space is required to accomodate wastes, more land should be cleared - so as to minimize erosion and negative aesthetic effects.

Permanent all-weather access roads leading from the public road system to the site entrance must be constructed so as to withstand anticipated traffic (i.e. collection vehicles). In the case of a site with a large working area, a temporary track leading from the site entrance to the active area is also necessary.

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17 The reader is referred to Weiss, Samuel, 1974. Sanitary Landfill Technology. Noyes Data Corporation, Park Ridge, New Jersey and to ASCE Solid Waste Management Committee of the Environmental Engineering Division, 1976. Sanitary Landfill.

If access roads are in proximity to residences, provisions for dust control in the summer season should be made.

In the case of a large site, (eg a regionalized site) where at least one full-time employee is present at the site, it is necessary to provide employee facilities; because the landfill operates year round, the building must be winterized. The building may also be constructed so as to provide for equipment storage and maintenance. The design and location of the structure should consider gas movement and differential settlement caused by decomposing solid wastes.[18] The building should be provided with electrical and sanitary services. Water for drinking, fire fighting, dust control and sanitation must be made available.

Regulation 208/76 requires all disposal sites to be fenced according to stated specifications. A peripheral fence surrounding the entire site area has a multiple use:

- controls or limits access to the site
- keeps out children, dogs and large animals
- screens the landfill from public sight
- clearly delineates the property line

If the working area is relatively small, the peripheral fence will also serve to control blowing paper. In the case of a larger site, where the working area is constantly shifting, a moveable litter fence

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18 Weiss, Samuel, 1974.

could serve this purpose.

It is questionable whether or not a gate should be installed at a site; although this is the only way in which access to the site can be controlled or limited to specified dumping hours, the experience of the municipalities in the study area in this regard have been negative. At those sites where access has been limited by a gate, residents feeling that as taxpayers they should enjoy unlimited access, dumped garbage along the gate and access road. This experience has made most municipalities and towns remove the gate from the disposal site. Unfortunately, if there is no gate, indiscriminate dumping and scavenging cannot be controlled during those times when there is no operator on site. This can result in accidents, the dumping of inadmissable items, such as the carcasses of farm animals or the open burning rubbish, such as waste rubber.

For a large ground with a machine at the site on a permanent basis, a regular cleanup of areas outside the fence and gate would be a relatively minor task. If the site were maintained only on a monthly basis, this system would not work. If the dumping hours were advertised and generally well-known, the problem of dumping after hours outside a gate would be minimized.

3.2.2. Leachate

Groundwater or infiltrating surface water moving through solid wastes can produce leachate, a solution containing dissolved and finely suspended solid matter and microbial waste products.[19] Leachate may

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19 The author has drawn freely from Weiss, Samuel, 1974.

leave the fill at the ground surface or percolate through the soil and rock that underlie and surround the waste. The composition of the leachate is dependent on the solid waste composition and on physical chemcial and biological decomposition activities within the fill. The types and quantities of contaminants entering the surface or ground water systems and the ability of the water to assimilate these contaminants will determine the degree of leachate control needed. Leachate percolating through soils underlying and surrounding the solid waste will be partially purified by ion exchange, filtration, absorption, complexing, precipitation and biodegradation. The degree of purification will be largely dependent on whether the leachate moves through un saturated or through saturated regions.

Leachate production is generally attributed to infiltration of water entering the landfill from outside i.e., precipitation.[20] The total amount of infiltrating water contributing to leachate production is that which enters the landfill less that which is lost to evapotranspiration and internal lateral flow within the cover material.

The quantity of water that can infiltrate the soil cover of a landfill thus increasing the rate of decomposition and eventually causing leachate problems, depends on the permeability of the cover material. Permeability is affected by texture, gradation and structure of the soil and the degree to which it has been compacted. Table 3.2 is a guide for assessing the general suitability of a site in regard to soil type; criteria #3 rates soil types in terms of permeability.

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20 Although water is generated as a product of refuse decomposition (the moisture content of mixed solid waste is about 30%), this is not thought to be significant in leachate production.

Table 3.2 - Suitability of General Soil Types as Cover Material

FUNCTION (1)	CLEAN GRAVEL (2)	CLAYEY-SILTY GRAVEL (3)	CLEAN SAND (4)	CLAYEY-SILTY SAND (5)	SILT (6)	CLAY (7)
1 Prevent rodents from burrowing or tunneling	G	F-G	G	P	P	P
2 Keep flies from emerging	P	F	P	G	G	E[a]
3 Minimize moisture entering fill	P	F-G	P	G-E	G-E	E[a]
4 Minimize landfill gas venting through cover	P	F-G	P	G-E	G-E	E[a]
5 Provide pleasing appearance and control blowing paper	E	E	E	E	E	E
6 Grow vegetation	P	G	P-F	E	G-E	F-G
7 Be permeable for venting decomposition gas[b]	E	P	G	P	P	P

a Except when cracks extend through the entire cover.

b Only if well drained

Note: E = excellent; G = good; F = fair; P = poor

Source: ASCE, Sanitary Landfill, 1976.

Leachate from a landfill can migrate into the underlying groundwater system and contaminate it; to know whether or not this will occur it is necessary to determine the location of the zone of saturation, the quality of the groundwater, the direction and flow of the aquifer and the permeability characteristics of the underlying rock strata.

Leachate generation can be migrated by avoiding contact between groundwater and waste materials, diverting surface waters away from the fill, preventing infiltration of precipitation into the fill by properly covering the refuse, by maintaining good drainage during operation and by properly compacting and grading the final soil cover when filling activities are completed.[21]

The geology of the test area has been briefly described in Chapter 1. When choosing a site for a regionalized disposal ground in the test area in terms of hydrogeologic suitability, two limiting factors must be considered.

a. The unpredictable pattern of the frequent occurance of local aquifers due to the interposition of sand/gravel lenses between layers of clay; this situation makes it necessary to consult groundwater log sheets before deciding upon a site.
b. the extensive area covered by the "Winkler Acquifer" must also be avoided.

These two constraints severely limit the number of suitable

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[21] A.S.C.E. 1976.

sites and this will be a major problem in the planning of a regionalized waste disposal ground.

CHAPTER FOUR

COMPONENT COSTS

4.1 Introduction

This study proposes a regional scheme as a means of mitigating many of the problems discussed in Chapter 2. This chapter presents a comparison of the cost components of a regionalized landfill (i.e., Scenario 1) and a single site (i.e., Scenario 2). For the purposes of this study only, it is proposed that a regionalized site, serving the residents of Morden, Winkler and the R.M. of Stanley, be located in the approximate area, off Highway #3, between Morden and Winkler. This location would be in proximity to the major waste producing centres of Winkler and Morden. It is proposed, again for purposes of this study, that the present Morden landfill site serve as the model for the costing of a single site (i.e., Scenario 2), in terms of the population and waste generation patterns. In all other aspects, the model complies with the following basic assumption, under which the comparison of the cost components between Scenario 1 and Scenario 2 is carried out:

i. that all regulations as set forth in the new legislation are complied with as of year 1, 1976; furthermore, that regulations are complied with in the least-cost manner.

ii. that cost estimates will reflect as accurately as possible the costs incurred by Morden, Winkler and Stanley; actual costs are used where they

Table 4-1

Population and Waste Generation Rates in the Test Area

Population	[a]Town of Morden	[a]Town of Winkler	Subtotal	[a]R.M. of Stanley	Total
1976	3816	3741	7557	4566	12,123
1977	3892	3816	7808	4657	12,365
1978	3970	3982	7862	4750	12,612
1979	4050	3970	8020	4845	12,865
1980	4131	4050	8181	4942	13,122
1981	4213	4131	8342	5041	13,385
1982	4297	4213	8510	5142	13,652
1983	4383	4297	8680	5245	13,926
1984	4471	4383	8854	5350	14,204
1985	4561	4471	9032	5457	14,488
Waste Generation Rates (lbs/day)	[b]	[b]		[c]	
1976	15,264	14,964	30,228	5479	35,707
1977	16,191	15,875	32,066	5821	37,887
1978	18,225	17,865	34,042	6175	40,217
1979	18,225	17,865	36,090	6541	42,631
1980	19,333	18,949	38,282	6919	45,201
1981	20,517	20,113	40,630	7360	47,990
1982	21,743	21,318	43,061	7816	50,877
1983	22,792	22,602	45,394	8287	53,681
1984	24,456	23,975	48,431	8777	57,208
1985	25,952	25,431	51,383	9332	60,715
Total	201,663	197,944	399,607	72,507	472,114

[a]population increase by 2% per year.

[b]generation rates of urban centres of Morden and Winkler increases by 4% annually.

[c]generation rates of rural area based on a 1976 rate of 2.25 lbs.cap/day; this rate increases by 4% annually.

Table 4-2 Scenario 1 : Land Requirements for a Co-operative Landfill

Yr.	Yr. No.	[a] Daily Production (lbs/day)	[b] Daily Compacted Volume (yd^3/ day)	[c] Annual Compacted Volume (yd^3/ yr)	[d] Total Annual Cover Material (yd^3/ yr)	Total Annual Trench Volume (yd^3/yr)	[e] Annual Surface Area Req'd for Trench (ft^2 /yr)	Annual Acreage for Trench (acres/yr)	[f] Total Acreage (annual) (acres/yr)
1976	1	35,707	35,71	9,284.6	2321.15	11605.75	31652.05	0.727	0.945
1977	2	37,887	37.89	9,851.4	2462.85	12314.25	33584.32	0.771	1.002
1978	3	40,217	40.22	10,457.2	2614.30	13071.50	35649.55	0.818	1.063
1979	4	42,631	42.63	11,083.8	2770.95	13854.75	37785.68	0.867	1.127
1980	5	45,201	45.20	11,752.0	2938.00	14690.00	40063.64	0.920	1.196
1981	6	47,990	47.99	12,477.4	3119.35	15596.75	42536.59	0.978	1.270
1982	7	50,877	50.88	13,228.8	3307.20	16536.00	45098.18	1.035	1.346
1983	8	53,681	53.68	13,956.8	3489.15	17445.95	47579.86	1.092	1.420
1984	9	57,208	57.21	14,874.6	3718.65	18593.25	50708.86	1.164	1.513
1985	10	60,715	60.72	15,787.2	3946.80	19734.00	53820.00	1.236	1.607
Total				122,748.6	30,687.15	153,435.75	418,461.12	9.607	12.489

a Based on production rates given in Table I.

b An in-fill compaction density of 1,000 lbs/yd^3 is assumed.

c A 5-day week, 260 day -year is assumed.

d A 4:1 refuse: cover ratio is assumed.

e A 10' deep trench is assumed.

f 30% over actual trench is allowed for a working area.

can be obtained; where this is not possible, capital costs are estimated based on the guidelines suggested by Gutherie.[1]

iii. populations for the test area are based on 1976 Census of Canada, Preliminary Population Counts for the Province of Manitoba.

iv. the populations of the towns of Morden and Winkler and the R.M. of Stanley are assumed to grow at a rate of 2% annually, beginning in year 2, 1977.

v. the urban (i.e., Morden and Winkler) generation rate of solid waste in year 1, 1976 is assumed to be 4 lbs./cap./day; this rate is assumed to increase by 4%/yr. from year 2 to year 10 inclusive.

vi. the rural generation rate is assumed to be 1.2 lbs./cap./day in 1976 and is assumed to increase annually by 4%/yr.

vii. it is assumed that in cases where the present disposal site must be expanded or relocated because of future land requirements and/or environmental and social considerations, land can be acquired either:

- adjacent to the present site,

or

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[1]Gutherie, K.M., "Capital Cost Estimating," Chemical Engineering, (March, 1969): pp. 114-142.

- at a new site with suitable access.

This assumption is based on a requisite assumption which states that the administration involved is willing to pay the price required to persuade an owner to sell a relatively small parcel of land for purposes of a waste disposal ground. In other words, no land-price constraints are assumed.

ix. it is assumed that landfill site users include only those persons designated as rural municipality or town residents; i.e., non-residents will be assumed not to use the facilities in Scenarios 1 and 2; this does not accurately reflect the actual situation, where residents will use that site which is most convenient for them.

x. it is assumed that each facility operates on a 10-year planning horizon; this means that facilities are planned to accommodate only 10 years' accumulation of wastes.

Table 4.1 shows projected population and waste generation trends from 1976 to 1985 for the R.M. of Stanley and the towns of Morden and Winkler. The figures in column 1, "Town of Morden", are those used in the costing of Scenario 2. The figures in the last column, "Total", are those used in the caluculation of costs for Scenario 1.

4.2 Regionalized Site Costs - Scenario 1

4.2.1 Initial Capital Investment

a. Land Costs

Under the terms of regulation 208/76 a total of 13 acres for a 10-year operating period is required for a co-operative landfill (see Table 4.2 for calculation of land requirements for a regionalized site over a 10-year period).

The assessed value of 1 acre of land in the general area between Morden and Winkler, along Highway #3, averages $65/acre. This value is considerably higher than elsewhere in the municipality; for example, the marginal farmland (i.e., stoney and rolling terrain) in the area of the Stanley "dump" is assessed at an average of $20/acre. If the assessed value is assumed to be 10% of the actual market value, then the market price of land (assessed at $65/acre) in the proposed area for a co-operative landfill site is about $650/acre. Because of the problems associated with the acquisition of land for waste disposal, it is anticipated that actual prices for a landfill site will be considerably higher than the market price.

Municipal officials from the study area quoted 1976 prices ranging between $1,500 and $2,000/acre for land used for disposal purposes. This study assumes a selling price of $1,500/acre. Land for a co-operative site can therefore be estimated to cost: $1,500/acre x 13 acres = $19,500.

b. Equipment

The machine assumed to satisfy the basic requirements for small landfill operations[2] is a small tractor-loader such as the

[2]Caterpillar Handbook designates a "small" operation as one that handles less than 35 tons of refuse per day.

Caterpillar Tractor model 941-B. The F.O.B. Winnipeg price (1976) of a 941-B including a 1.5 yd^3 multiple purpose bucket and a canopy (a safety feature which is likely to become compulsory in the next 2 years) is $51,291.00. This quote does not include provincial sales tax.

c. Bare Building Costs

A frame building for housing the equipment which is partitioned and insulated to serve as an employee facility is required for the site. The building will house an earth-moving machine of a size equivalent to a caterpillar tracter 941-B Crawler Loader.

A building 15 feet high with a 40' x 20' = 800 ft^2 floor space is assumed. Gutherie[3] describes a building suitable for a garage as being of a prefabricated medium steel frame and roof, transite or metal sheet walls, concrete floor, minimum furnishing and accommodations inside. Brown and Lebeck[4] give a cost of $3.61/$ft^2$ for such a building; this estimate is based on Gutherie.[5] The total cost for labour and materials, adjusted for 1976 prices[6],

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[3] Gutherie, K.M. 1969.

[4] Brown and Lebeck, 1976.

[5] Gutherie, 1969.

[6] a 10% annual increase from 1973 to 1976 has been used to adjust costs to accommodate inflationary increases and the generally higher prices for labour and materials in Canada; labour costs are based on a $4.80/hr. wage rate, for 1976.

can be estimated as follows: ($4.81/ft^2) (800 ft^2) = $3843. This figure compares closely with estimates for materials given by Sutherland Catalogue, Winnipeg, 1976.

d. Building Improvements

In order that the building serve as an employee shelter, certain improvements must be made. Cost estimates are based on 1968 capital cost estimates for industrial building services given by Gutherie.[7]

Service	$/sq. ft.(1968)	$/ft^2 (1976)
plumbing (general)	1.21	2.59
heating & ventilating	1.00	2.14
lighting & electrical	.70	1.50
TOTAL	2.91	6.23

Thus, a building of 800 ft^2 will result in a total cost of $4984.00 for building improvements. This estimate compares closely with local figures. However, since it would not be necessary to heat and service with water the building section used for equipment storage, the real cost of building improvements may be slightly less.

e. Fencing Costs

The only stipulation contained in Regulation 208/76 concerning fencing for class I disposal sites is that the active area be enclosed with a fence at least 6' in height constructed in such a manner so as to contain the solid waste within the working area. For this study costs are based on a 6" square light metal fence, 60" high (costs would be higher for a 6' height - the required

[7]Gutherie, 1969; costs estimates use a $4.80/hr. wage rate and adjusted for 1976 prices (i.e., compounded at 10% for 8 years); cost estimates include labour and material costs.

height; estimates for this were not available). Total labour costs, based on a $4.80/hr. wage rate, are derived from the labour: material ratio (L/M) given by Gutherie. Because Gutherie's cost/ft. for a fence (materials only)[8] is 1.43 times as great as Winnipeg 1976 quotes, the L/M ratio has been adjusted accordingly.

Assuming that the required acreage for a 10-year operating period is purchased in year 1 (1976), and further assuming that the entire area, including the active area, is fenced in year 1, then the capital costs can be calculated. Calculations, presented in Table 4.3, are based on a fenced site of approximately 13 acres or 3010 linear ft.

Table 4.3 Fencing Costs for a Regionalized Site

1. Materials

Item	Unit Cost	Total Cost (1976)
Fence	$0.295/ft.[a]	$887.00 [b]
1 post/6 feet of fence	3.25	$1630.00
1 gate		120.00
Total		$2638.00

2. Labour

Using a L/M ratio of 0.27[c], labour costs for erecting a fence are (2638.00) (.22) = $580.00

3. Total Cost for Fence $3,799.00

[a]All Cost estimates for fencing are taken from Gutherie, K.M. "Capital Cost Estimating". Chemical Engineering. (March 1969): pp. 114-142.

[8]Winnipeg quotes for materials based on Sutherland Supply Catalogue, 1976.

[b]Acreage shape is based on the most economical and workable area: perimeter ratio; i.e., a square figure.

[c]Gutherie, "Capital Cost Estimating".

f. Access Roads

The actual length of road required for site access will be determined by the terrain at the site and by the proximity of the site to improved roads. The proposed area for a co-operative site is approximately 1-2 miles off highway #3 joining Morden and Winkler; therefore, for calculation purposes, 1.5 miles is assumed to be typical access road length, with a road 10 feet wide. Cost estimates are based on current (1976) rates paid by the rural municipality of Morris to a private gravel contractor. These rates are as follows:

Hauling cost: $\$0.12/mi/yd^3$

Material and labour cost: $\$1.50/yd^3$[9]

It is assumed that a 2" gravel layer is a reasonable mean requirement. It is further assumed that appropriate site seletion will allow roads to be routed without extensive grading; grading costs are not included in the estimates. The required road maintenance is assumed to be part of regular municipal maintenance. This assumption is based on a requisite assumption that states that the combined distance from a public road to each of the three existing sites in the test area equals 1.5 miles, the assumed length of the access road to the proposed regionalized site. It is also assumed that the hauling distance for gravel is 10 miles, i.e., hauling cost is therefore $\$1.20/yd^3$. This figure is an arbitrary one because it is not known from where gravel for a regionalized site will be obtained.

[9]This rate includes crushing, loading and spreading costs.

The initial access road costs can be estimated as follows:

1.5 miles (8,800 yds^3) of 2" thick gravel @ a total cost of $2.70/$yd^3$ (materials, labour and hauling) = $1,320.00

g. Gas and Leachate Monitoring and Control Installations

Regulation 208/76 specifies that class I disposal grounds shall have installed, gas monitoring, gas venting system and ground-water monitoring wells. It is assumed that such installations will cost approximately 10% of the total annual variable costs, i.e., 10% of $18,861.00 = $1,886.00. This cost figure includes the cost of both labour and materials.

h. Close-down and Reclamation Costs and Salvage Value of Old Sites

A plan for a regionalized sanitary land-fill site will necessitate the closing down of the three existing sites in the test area. This will incur certain costs attributable to rat extermination, fire extinguishing and grading, compacting and covering the old site.[10]

This section discusses the costs related to closing a site, the reclamation of old sites and the salvage value which can be attributed to them.

The costs of closing down an old site of approximately the size of the Morden site is roughly estimated to be $300.00. This total can be broken down in the following way:

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[10] Brunner, Dirck, R. et al., Closing Open Dumps Environmental Protection Agency. Solid Waste Management Office. 1971. pp. 19.

rat extermination	$100.00
extinguishing fires	2 days work
grading, compacting and covering	machine cost $7.48/hr[11] labour costs $4.80/hr Total: 16 hrs @ $12.28/hr = $200.00
TOTAL	$300.00

A landfill site itself is, in the long-term view, only an interim use of the site. When the site has been used up or is closed down for some other reason, the land can be made available for other uses which may have a life much longer than that of the original filling operation. Because problems related to settling, corrosion and gas movement extend beyond the life of the fill itself, landfills are most usually reclaimed for recreational or agricultural purposes.[12]

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[11] Machine costs are detailed in section 4.23.

[12] A.S.C.E. Solid Waste Management Committee of the Environmental Engineering Division. Sanitary Landfill

This study assumes that the 3 closed sites will be developed and sold to private buyers as pasture land. This plan is quite appropriate for the Stanley and Morden sites which are located in a rural, agricultural area; the Winkler site however, is located on the edge of the town, bound on one side by industrial buildings. Development of a pasture in such an area may be questioned; however, for the purposes of simplifying the estimation of costs, this study assumes that all three sites are reclaimed in an identical manner.

The initial cost of pasture development on the 3 sites are estimated below:[13]

Item	Cost Per Acre ($)
Breaking and seeding (exclusive of seed costs)	12
Seed	10
Fertilizer	25
Total	47

It is assumed that pasture developed from old landfill sites can be sold for $150/acre. The net salvage value of the land is therefore approximately $100/acre (excluding closing down costs).

4.2.2 Annual Fixed Costs

a. Depreciation Costs

A building life of twenty years is assumed with yearly depreciation costs of ($3843 + 4984)/20 = $441. The building is

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[13] Estimates are based on those found in Wiens, J.K. and R.W. Lodge. Developing Bush Pastures Canada Department of Agriculture. 1972

assumed to have no salvage value at the end of 20 years.

The fence is assumed to have a total usable life of twenty years with no salvage value after this period. Annual depreciation costs are 3799/20 = $190.

The expected life of the 941-B Caterpillar is given as 10,000 hours of operating time;[14] an expected life of 10 years or 1,000 hours annually is assumed in this study. A salvage (i.e. scrap) value of 10% the initial purchase (i.e. 10% of 51,291 = $513.) is assumed. The annual depreciation costs of a 941-B caterpillar can therefore be calculated as follows: $\frac{51,291 - 513}{10}$ yrs. = $5077.00[15].

The land for a co-operative site has a useful life as a landfill of 10 years. The net resale value after this time and after the land has been developed as pasture has been calculated to be approximately $100/acre. The annual depreciation costs can be calculated as follows:

$$\frac{(13 \text{ acres})(\$1500/\text{acre}) = (13 \text{ acres})(\$100/\text{acre})}{10 \text{ years}} = \$1820.00$$

b. Cost of Capital

The cost of capital for the initial investment has been based on the current market rate for issued long-term (i.e. 10 years) debentures

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[14] Caterpillar Performance Handbook, 1976

[15] It should be noted that the method used to determine annual depreciation costs is not based on or related to any tax considerations. It is a simple, straight line method based solely on hours of use.

in Manitoba -- approximately 10%. Table 4.4 estimates the cost of capital of the fixed investment for a regionalized site.

Table 4.4 Cost of Capital Fixed Investment

Item	Expected Life (yrs)	$(P_i - P_s)i/E$*	Total
Building	20	(.1)(8827 - 0)/20	44.0
Equipment	10	(.1)(51.291 - 513)/10	508.0
Fence	20	(.1)(3799 - 0)/20	19.0
Land	10	(.1)(19500 - 1300)/10	182.0
TOTAL			713.0

* P_i - initial price; P_s = salvage value i = municipal bond rate; E = expected life of item.

c. Insurance Costs

Annual insurance costs for the equipment are calculated on the basis of a 3% insurance rate with an annual assumed operating time of 1000 hours.[16] Using the method outlined in the Caterpillar Performance Handbook, 1976, annual insurance costs can be calculated as:

(0.015) (51,294) = $769.00

16 A Winnipeg insurance broker estimated that an adequate rate ranged from 1 - 3% depending upon the use of the equipment. Caterpillar Performance Handbook 1976 recommended a rate of 3% as do Brown, F. Lee et al, 1976. op. cit.

4.2.3 Annual Variable Costs

a. Maintainance

1. Equipment

The hourly operating costs for a 941-B Caterpillar are shown in Table 4.5. These costs have been calculated using the format given in the Caterpillar Performance Handbook(1976).

There are considerable difficulties in estimating the actual annual operating time (in hours) for the co-operative landfill site. The only source which speculates on equipment operating times for landfills of the magnitude considered in this study is Brown and Lebeck.[17] From this source, it can be estimated that for a population of 13,500[18], an annual machine rate of 845 hours is a reasonable approximation of the actual number of operating hours; this figure is based on an average operating time for a 941-B Caterpillar of 1.13 hr./ton.[19] This estimate of annual operating hours for a 941-B includes the time required for digging the initial trenches, moving refuse and compacting it, applying a 6" compacted cover layer, applying a final cover layer, and moving extra

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17 Brown and Lebeck. 1976

18 This figure is assumed to be the median of the range of populations assumed in this study for the test area, from year 1, 1976 to year 10, 1985 (see Table 4.1)

19 Brown and Lebeck, pp. 63-65.

trench dirt and spreading it.

The annual maintenance costs can now be calculated: hourly operating costs (excluding labour) x number of operating hours/year = $7.48/hr x 845 hrs/yr = $6,320.00

ii. Building

The cost of servicing the frame building on site (i.e. electricity, heat and water) is estimated to be $200.00/yr[20]. Building maintenance is estimated to be $150.00/yr.[21]. Total costs are therefore $350.00.

Table 4.5 Calculation of Hourly Operating Costs for a Caterpillar Tractor Model 941-B

1. Fuel	
Unit Price[b] x Consumption[c]	
$0.75/gal. x 3.4 gal.hr. = $2.55 hr.	$2.55
2. Lubricants, Filters, and Grease[d]	
Hourly Cost of Filters = $0.0565	
Hourly Cost of Lubricants + Grease = $0.268	
Total $0.31965	$0.31965
3. Repairs	
Factor[e] x Delivered Price/1000	
(0.09) x ($51,291.00)/1000 = $4.61 hr.	$4.61
4. Total Hourly Operating Cost (Excluding Labour)	$7.48

20,21 Ibid.

a. Calculations are based on the format suggested in the Caterpillar Performance Handbook, 1976.

b. Winnipeg price of diesel fuel as of March, 1977.

c. Based on the Caterpillar Load Factor Guide for fuel consumption, Caterpillar Performance Handbook, 1976.

d. Based on 1976 F.O.B. Winnipeg prices, excluding provincial sales tax; procedure for calculating hourly cost based on format suggested by Caterpillar Performance Handbook, 1976.

e. Caterpillar Handbook "Zone B" assumed to represent operating conditions for machinery in the test area.

f. F.O.B. Winnipeg, 1976 price excluding provincial sales tax.

iii. Fencing

Fence maintenance which includes painting and repairs, is assumed to be $100/yr. for each 1000 feet of fence; thus total annual costs for fence maintainance are $301.00.

b. Labour

It is assumed that one full-time employee is sufficient for proper operation of a regionalized landfill site.[22] Work time of the employee would presumably be divided between two tasks:

- acting as a general, on-site supervisor to prevent improper dumping, burning and scavenging,
- as a machine operator, compacting, spreading and covering the solid wastes; based on an annual machine rate of 845 hours, time spent operating the 941-B Caterpillar would be approximately 3.25 hrs./day.

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22 A landfill serving a population greater than 17,000 would require 1.5 full-time on-site employees.

A wage rate of $4.80/hr. in year 1,(1976) is assumed to be a fair rate for a heavy-equipment operator; this is the rate used by Gutherie in estimating other on-site costs (such as ereetion of a fence and a frame building).[23] It is also assumed that the wage rate will increase annually from year 2 to year 10 at a rate of 4%. This assumption is based on the requisite assumption that annual increases in waste generation/capita are correlated to annual increases in real income; since this study assumes an annual increase of 4% in the per capita waste generation, it is assumed that the real income of people in the test area will also increase at approximately this rate.

For calculation purposes, the median wage rate has been used, i.e. the rate in year 5 (1980); this rate is calculated to be $5.62 /hr. Annual labour costs can therefore be calculated as follows: 1 full time on-site worker @ ($5.62/hr) (8 hr/day)(260 days/yr) = <u>$11,690.</u>

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23 Gutherie, 1969.
This is also roughly equivalent to the rate recommended by the Heavy Construction Wage Board, Dept. of Labour, Manitoba, for 1976.

4.24 Cost Summary for a Regionalized Landfill Site

The initial capital investment and the annual fixed and variable costs of a regionalized landfill site serving a median population of 13,500, are summarized in Table 4.6.

Table 4.6 Cost Summary for a Regionalized Landfill Site

	Cost ($)
1. Initial Capital Investment	
a. Land (13 acres @ $1500/acre)	$ 19,500.
b. Equipment (941-B tractor loader)	51,290.
c. Frame Building (including labour)	3,843.
d. Building Improvements (including labour)	4,984.
e. Fence (including labour)	3,799.
f. Access Road (including labour)	1,320.
g. Gas & Leachate, Monitoring and Control installations	1,886.
Total Capital Investment	86,622.
2. Fixed Annual Costs	
a. Depreciation	
i. Land (depreciated over 10 yrs.)	1,820.
ii. Equipment (depreciated over 10 yrs.)	5,077.
iii. Frame Building (depreciated over 20 yrs.)	441.
iv. Fence (depreciated over 20 yrs.)	190.
Sub-total	7,528.
b. Cost of Capital	
i. Land	44.
ii. Equipment	508.
iii. Building	19.
iv. Fence	182.
Sub-total	713.
c. Insurance	
i. Equipment	769.
Total Fixed Annual Costs	9,010.
3. Variable Annual Costs	
a. Maintenance	
i. Equipment	6,320.
ii. Building	350.
iii. Fence	301.
Sub-total	6,971.
b. Labour	
i. One full time employee	11,690.
c. Miscellaneous (contingency fund)	200.
Total Variable Annual Costs	18,861.
4. Total Annual Costs	27,871.

4.3 Single Site Costs - Scenario 2

This section presents a cost schedule for a landfill site serving approximately 5,000 persons. The cost components considered include start-up costs as well as the annually incurred costs of operation. The operation depicted in this scenario approximates the situation of each of the 3 disposal sites in the test area; however, in order to provide a reasonable basis for comparison of the cost/capita of a regionalized site vs. a single site it is necessary to somewhat idealize the actual situation; for this reason, the estimation of costs has been carried out under the following set of assumptions:

a. the landfill is operated as a Class I Sanitary Landfill site according to the specifications of regulation 208/76; the population and waste generation patterns of the town of Morden (Tables 4.1 and 4.7) are used as the models for the costing of this scenario. Although the official population (i.e. Census Count, 1976) is just under 5,000, the actual population served by the Morden Landfill is estimated by town officials to be presently over 5,000.

b. the new sites be located in the same general area as the present site, i.e., about 3 miles west of Morden.

c. that a part-time employee, acting as a machine operator and a general, on-site supervisor is assigned to clean-up and cover daily waste accumulates. The daily machine clean-

Table 4-7 Scenario 2 – Land Requirements for Town of Morden Landfill Site

Year	Yr. No.	[a] Daily Production (lbs./day)	[b] Daily Compacted Vol. (yds.^{3}/ day)	[c] Annual Compacted Vol. (yds.^{3}/ yr)	[d] Total Annual Cover Material (yd.^{3}/ yr)	Total Annual Trench Volume (yd.^{3}/ yr)	[e] Annual Surface Area Req'd for Trench (ft.^{2} /yr)	Annual Acerage for Trench (acres/yr)	[f] Total Annual Acerage (acres/yr)
1976	1	15, 264	15.26	3,967.6	991.90	4,959.5	13,525.91	0.31	0.40
1977	2	16, 191	16.19	4,209.4	1,052.35	5,261.75	14,350.23	0.33	0.43
1978	3	17, 190	17.19	4,469.4	1,117.35	5,586.75	15,236.59	0.35	0.46
1979	4	18, 225	18.23	4,739.8	1,184.95	5,924.75	16,158.41	0.37	0.48
1980	5	19, 333	19.33	5,025.8	1,256.45	6,282.25	17,133.41	0.39	0.51
1981	6	20, 517	20.52	5,335.2	1,333.80	6,669.00	18,188.18	0.42	0.55
1982	7	21, 743	21.74	5,652.4	1,413.10	7,065.50	19,269.55	0.44	0.57
1983	8	22, 792	22.79	5,925.4	1,481.35	7,406.75	20,200.23	0.46	0.60
1984	9	24, 456	24.46	6,359.6	1,589.90	7,949.50	21.680.45	0.50	0.65
1985	10	25, 952	25.95	6,747.0	1,686.75	8,433.75	23,001.14	0.52	0.68
Totals				52,431.6	13,107.9	65,539.50	178,744.08	4.10	5.33

a Based on production rates given in Table I.

b An in-fill compaction density of 1,000 lbs/yd 3 is assumed.

c A 5-day week, 260 day-year is assumed.

d A 4:1 refuse: cover ratio is assumed.

e A 10' deep trench is assumed.

f 30% over actual trench area is allowed for a working area.

up time required for a population of 5,000 producing 10 tons of waste/day (based on 1976 urban generation rate), can be calculated as follows:

(0.1300 hr./ton) (10 tons/day) = 1.3 hrs./day.

This study assumes that a municipal/town employee is assigned to the site for 4 hours/day. (2 hrs. machine time and 2 hr. general supervision and maintenance). Other duties unrelated to the disposal site are assigned to the worker in order to complete a full, 8-hour work day.

d. that a new, 941-B tractor loader is purchased in year, 1 1976. It is assumed that this machine will perform daily cleanups at the disposal site and will also be occassionally assigned to other municipal tasks, such as road clearing in the winter, earth moving, gravel excavation and other tasks suitable for a machine with a multiple purpose bucket. It should be noted that because the site is located some distance from town, the assignation of the machine to tasks other than disposal clean-up, may only occur on a sporadic basis. Thus, this study assumes that only 25% of the total machine capacity is used for tasks unrelated to the disposal operation. The initial capital cost for a disposal maintenance machine is prorated on this basis: 75% of $51,290 = $38,468.00

e. that a building with the same dimensions as in scenario 1, be erected.

f. that a 60" high, 6" square fence be erected around the site.

Table 4.8 presents a cost schedule for a single site; except where otherwise noted, all cost estimates have been derived in a manner identical to that used for scenario 1.

Table 4.8 Cost Summary for an Individual Site

	Cost
1. Initial Capital Investment	
a. Land (6 Acres @ $1500/acre)[a]	9,000.00
b. Equipment (941B tractor loader)	38,468.00
c. Frame Building (including labour)	3,843.00
d. Building Improvements (including labour)	4,984.00
e. Fence (including labour)[b]	2,234.00
f. Access Road (including labour)[c]	440.00
Total Capital Investment	67,969.00
2. Fixed Annual Costs	
a. Depreciation	
i. Land[d]	840.00
ii. Equipment[e]	3,808.00
iii. Building	441.00
iv. Fence	112.00
Subtotal	5,201.00
b. Cost of Capital	
i. Land	84.00
ii. Equipment	508.00
iii. Building	44.00
iv. Fence	11.00
Subtotal	647.00
c. Insurance	
i. Equipment	769.00
Total Annual Fixed Costs	6,617.00
3. Variable Annual Costs	
a. Maintenance	
i. Equipment[f]	2,663.00
ii. Building	350.00
iii. Fence[g]	205.00
Subtotal	3,218.00
b. Labour	
i. one, part-time employee[h]	5,844.00
c. Miscellaneous	200.00
Total Annual Variable Costs	9,262.00
4. Total Annual Costs (2+3)	15,879.00

a. approximately 6 acres are required for a landfill serving an average of 5,000 persons for 10 years (see Table 4.7 for calculations).

b. fencing costs calculated on proportional basis of fence costs in scenario 1.

c. assumed to be 1/3 the length needed for a regionalized site; this assumption is a prerequisite for the assumption that since the length of the 3 individual access roads to dump sites in the test area equals the length of the road to the regionalized site, general road maintenance costs can be ignored.

d. Annual depreciation cost = (Initial Cost - Salvage Value)/ 10 yrs; therefore depreciation cost = (9000) - (6 acres) ($100/acre)/20 = $840.00

e. Annual machine depreciation costs are adjusted for the time spent on unrelated disposal costs: i.e. $5,077/yr x 75% = $3,808.00

f. Based on an average operating time for a 941-B Caterpillar of 0.13 hr./ton, a landfill serving a population of 5,000 persons will have an annual machine rate of 356 hours; thus annual machine main costs can be calculated as ($7.58 hr.) (356 hrs.) = $2,663.00)

g. Maintenance costs for fence calculated on a proportional basis of fence maintenance costs for a regionalized site.

h. (4hrs/day)(260 days/yr.)($5.62/hr.)= $5844.00

CHAPTER FIVE

RESULTS AND DISCUSSION

Table 5.1 compares the cost components for scenarios 1 and 2. The figures indicate that both the initial and the annual costs are significantly lower for the larger, regionalized site. The ratio of the population in scenario 1 to the population in scenario 2 in year 1(1976) is 2.7 but the ratio of the total annual costs in scenario 1 to the same costs in scenario 2 is only 1.93. It is 1.3 times as costly on a per tonnage basis for disposal of wastes in scenario 2 compared with the unit cost in scenario 1.

Table 5.1 Comparison of Cost Components for Scenario 1 and 2

	Scenario 1	Scenario 2	C_1/C_2	C_2/C_1
1. Initial Capital Investment(I.C.I.)	$86,622	$67,969	1.27	7.85
2. Annual Fixed Costs	9,010	6,617	1.36	7.34
3. Annual Variable Costs(A.V.C.)	18,861	7,802	2.42	4.14
4. Total Annual Costs(T.A.C.)	27,871	14,419	1.93	5.17
5. Cost/Capital(of I.C.I.)	6.42	13.60	0.47	1.58
6. Cost/Capita(of T.A.C.)	2.07	2.88	0.72	1.39
7. T.A.C./Ton Waste*	4.75	6.32	0.75	1.33

*Based on year 5(1981) population and waste generation figures; see Table 4.1

Table 5.2 shows the unit cost figures for populations varying from 250 to 40,000 persons.[1] These cost estimates, which were derived using methods similar to those used in this study, agree well with the estimates derived in this study.

Table 5.2 Unit Cost for Landfill Sites

Population	Tons/Year	Unit Cost ($/ton)
250	137	$129.00
500	274	64.70
1,000	548	32.69
5,000	2,738	7.16
10,000	5,475	3.98
20,000	10,956	3.33
40,000	21,900	2.23

There are several weaknesses in the cost data which should be noted before any definite conclusions are drawn.

i. Some of the data may not accurately reflect real costs because certain assumptions were made in order to determine a representative or "average" cost; examples of this are the figures estimating the hauling costs of gravel for access routes.

ii. Because of the difficulty in estimating the number of manhours required for certain site development tasks

1 Brown and Lebeck, 1976 Cars, Cans and Dumps.

(eg. erecting a fence), it was impossible to determine labour costs directly; for this reason, it was necessary to rely on cost estimates and labour to material ratios given by Gutherie.[2]

iii. Because it is impossible to accurately predict future price trends, annual costs do not take into account real increases in the cost of fuel. This omission does not invalidate the results of the cost analysis because the cost component attributable to fuel is small compared with other cost factors.

iv. There may be variations between costs as outlined in this study and actual costs if, administrations undertaking to regionalize disposal services (Scenario 1) or to start up a new single site (Scenario 2), utilize heavy equipment, fencing and/or prefabricated shelters already belonging to the municipality or town; if such were the case, huge costs savings could be realized.

v. A few comments should be made about the differences in the financial structures within which private and public (i.e., municipal) administrations operate. Public budgeting by municipal administrations keep the amortization of initial capital outlays distinct from current expenses.

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2 Guthrie, 1969. "Capital Cost Estimating."

Because the full amount of all capital purchases is "written off" in the year of the purchase, no charge is made to current accounts for depreciation of the purchase. This study does account for annual depreciation costs, reflecting the loss in asset value resulting from a year's operation. Municipal budgeting does not include the cost of capital in assessing disposal costs: this study does include this factor in the cost analysis.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

a. The problems of rural waste disposal can be summarized as follows:

i. economic: Sanitary landfills on a small scale are a costly proposition; waste disposal is a low priority item and municipalities are reluctant to allocate funds for upgrading landfill sites.

ii. social: The site selection process for a landfill results in many land-use conflicts such as:

- adverse effects of landfill sites on surrounding properties (depreciation, nuisance, aesthetics).
- the fragmentation of section land.
- misallocation of community resources; i.e., the loss of prime agricultural land to uses (eg disposal) that do not require high class land.

iii. environmental: site criteria are governed by a set of hydrological and geological criteria; when these criteria are ignored, environmental pollution results.

b. It is possible to obtain significant economies of scale if waste disposal services are regionalized. However, economies will only be realized if regionalized sites are above a minimum size, i.e. serving populations greater than 8,000.[3] These economies are particularly significant in terms of the per capita cost of the initial capital investment necessary for setting up a landfill site.

c. A long term, co-operative approach to waste disposal on the part of rural municipalities and towns would allow local administrations to plan within the framework provided by the Planning Act.

d. A co-operative approach would enable municipalities to implement effective methods of mitigating many of the operational and environmental problems which plague small operations; such methods are generally considered too costly to be undertaken independently by one municipality. Centralizing disposal sites will also reduce the number of "trouble spots" which have a depreciating effect on property and which often act to fragment larger sections of agricultural land.

e. It is not possible to accurately predict future changes in policy regarding waste disposal sites; however, it is reasonable to conclude that a regionalized operation involving at least three rural administrations would be better able (financially) to respond to legislation requiring further upgrading of sites, than would a smaller scale of operation.

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3 See Table 5-2.

f. There are three major problems which will impede the process of regionalization of disposal in the study area:

i. Until recently, the reaction in many rural areas to the new Planning Act has been negative; this may stem from the fact that people do not understand the philosophy behind the Act, and more importantly, cannot comprehend the complexities of the Act itself. This negative attitude has and probably will continue to make rural residents hesitant about approaching the provincial authorities for any type of expertise related to waste disposal.

ii. Realization of the potential for efficient use of resources via co-operative efforts between municipalities rarely occurs because of inter-municipal conflicts arising when each jurisdiction naturally strives to promote its own interest. A current example of this type of conflict is found in an editorial in the Red River Valley Echo, Wednesday, July 14, 1976, which discusses conflicts between the town of Altona and the R.M. of Rhineland (these two administrations have participated in co-operative planning in the past - a garbage dump jointly serves the citizens of Altona and Rhineland). The editorial states that if local councils can see a way to overcome inter-municipal conflicts, they may be able to avoid " the provincial government imposing an unwanted form of government upon us."

iii. A few comments should be made about the new policy (Regulation 208/76) and its effects on rural area disposal. Cost analysis in this study assumed that municipalities and towns complied 100% with the specifications of the regulation. In actuality, this is not likely to occur because although the new regulation does not contain the ambiguities of the old regulations, neither does it specify any method of enforcement, other than the system of fines, (outlined in the C.E.A.) which is rarely utilized. Thus, the situation described in Chapter 2 will not change for officials trying to enforce the new regulation, i.e., Public Health Inspectors and Medical Officers of Health. Municipalities will probably not be put into the position of having to upgrade their disposal sites; without this incentive, it is doubtful that rural areas will see any need to regionalize disposal services.

6.2 Recommendations

The following recommendations are made:

a. That a comprehensive program of public education be implemented in Manitoba, in order to bring to the public attention the need for improved waste disposal methods and the dangers and problems of preserving the status quo. If public understanding and support can be obtained, the move to upgrade and/or regionalize waste disposal will be infinitely easier.

b. That a liaison position be created (between the municipalities and the provincial government,) by the provincial government in order to facilitate the flow of information concerning specific solid waste disposal problems. This would enable rural administrations to seek expert help in choosing new landfill sites and in eliminating operating problems of existing sites. At present, the store of knowledge and expertise found in such government departments as the Water Resources Branch and the Soil Pollution Branch of the Department of Mines, Resources and Environmental Management is not being fully utilized by those who sorely need it.

c. That the provincial government investigate the possibility of the provision of a subsidy system to be used by municipalities for the purpose of upgrading a site to the level required by Regulation 208/76 or for setting up a regionalized system of waste disposal. Both financial and technical support would be required if, for example, municipalities were to install the gas and ground water monitoring and control system required of Class I sites by the regulation.

d. That, given the implementation of the above programs and incentives, a system of financial penalties other than those contained in the C.E.A. and specific to the waste disposal situation, be instituted.

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APPENDIX A

Manitoba Regulation 208/76

Being a Regulation Under The Clean Environment Act

Respecting Waste Disposal Grounds

(Filed September 20, 1976)

1 In this regulation

(a) "active area" means the trench or berm confined area of a waste dispoal ground in which solid wastes are currently being deposited;

(b) "approved" means approved by the Department in writing;

(c) "berm" means an earthen structure enclosing an above grade active area constructed such that the outside slope of the berm does not exceed 3:1;

(d) "bulky metallic waste" includes but is not limited to derelict vehicles, farm machinery, and other large appliances which are capable of being salvaged for recycling or reuse;

(e) "Class I waste disposal ground" means a waste disposal ground serving a population in excess of 5,000 persons;

(f) "Class II waste disposal ground" means a waste disposal ground serving a population in excess of 1,000 persons; but less than or equal to 5,000 persons;

(g) "Class III waste disposal ground" means a waste disposal ground serving a population less than or equal to 1,000 persons;

(h) "dwelling" means a building or any part thereof that is used for living or business purposes;

(i) "grade" means the average horizontal elevation common to the waste disposal ground;

(j) "liquid waste" includes sewage, sewage effluent and sludge from septic tanks;

(k) "metallic waste compound" means an area of land separate from a waste dispoal ground, designated for the storage of bulky metallic waste'

(l) "operator" means a person responsible for the waste disposal ground;

(m) "solid waste" means all discarded waste materials excepting liquid waste and bulky metallic waste;

(n) "waste disposal ground" means an area of land designated by a person, municipality, provincial government agency, or crown corporation for the disposal of waste.

2 Any person operating or intending to operate a waste disposal ground is not required to file a proposal or register as provided for in subsection (1) and (4) of Section 14 of the Clean Environment Act.

3 Each municipality, provincial government agency and crown corporation shall make provision for the disposal of solid waste, liquid waste, and bulky metallic waste.

4 The operator of a new waste disposal ground shall register the waste disposal ground with the Department, on a form provided

by the Department, at least 30 days prior to its commencing operation.

5 The operator of an existing waste disposal ground shall:

(i) within one year of the effective date of this regulation register the waste disposal ground with the Department on a form provided by the Department; and

(ii) within two years of the effective date of this regulation ensure that the location and operation of the waste disposal ground are in compliance with the provisions of this regulation.

6. No person, unless otherwise authorized by the operator, shall enter a waste disposal ground except for the purpose of depositing waste.

7 Notwithstanding Section 5, dead livestock deposited in a waste disposal ground shall be buried within 24 hours of deposit with a minimum 1 m (3.3 ft.) of earthen cover.

8 Unless otherwise approved, the operator of a Class I waste disposal ground shall have installed at the waste disposal ground, in accordance with good and accepted engineering practice, gas monitoring probes, gas venting systems, and groundwater monitoring wells.

9 A waste disposal ground shall be:

(i) located so that wastes or leachings therefrom are contained within the boundaries of the waste disposal ground or do not contaminate water;

(ii) located where there is a separation between the base of the deepest layer of solid waste and the groundwater table of at least 1.5 m. (5 ft.);

(iii) located at least 31 m. (107.7 ft.) from the nearest edge of the right-of-way of any public road excepting the access road of the waste disposal ground;

(iv) located at least 402 m. (1,318.5 ft.) from any dwelling in existence at the time the waste disposal ground is established;

(v) serviced by an all weather road.

10 The operator of a waste disposal ground shall:

(i) implement control measures as necessary to prevent rodent and insect production and sustenance; and

(ii) surround, unless topographical features provide a natural berm, the active area of a waste disposal ground which is operated above grade with a berm constructed at least 0.6 m. (2 ft.) higher than the elevation of the solid waste.

11 Open burning in a Class I waste disposal ground is prohibited unless otherwise approved.

12 Open burning in Class II and Class III waste disposal grounds is permitted provided:

(i) there is no burning of rubber tires; and

(ii) the burning takes place in a trench or in a berm confined area.

13 A Class I waste disposal ground, unless otherwise approved, shall be operated in accordance with the requirements of Schedule A.

14 A Class II waste disposal ground, unless otherwise approved, shall be operated in accordance with the requirements of Schedule B.

15 A Class III waste disposal ground, unless otherwise approved, shall be operated in accordance with the requirements of Schedule C.

SCHEDULE A

WASTE DISPOSAL GROUND OPERATIONAL REQUIREMENTS

CLASS I

1 Solid waste shall be deposited in the active area.

2 Each single layer of solid waste deposited in the active area shall be compacted to a thickness of 0.6 m. (2 ft.) with not more than two compacted layers being placed prior to covering with a layer of earth, compacted to a thickness of at least 15 cm. (5.9 in.)

3 At the end of each day of operation, solid waste shall be covered with a layer of earth, compacted to a thickness of at least 15 cm. (5.9 in.)

4 Upon termination of use of an active area in excess of 0.4 hectares (1 acre), or upon closure of the waste disposal ground, a final cover of earth compacted to a thickness of at least

0.6 m. (2 ft.) shall be applied to the surface of the active area and the area shall be so graded as to minimize the ponding of water on the surface.

5 The active area shall be enclosed with a fence at least 1.8 m. (6 ft.) in height, constructed in such a manner as to contain the solid waste within the active area.

6 Where the municipality has not provided a metallic waste compound, bulky metallic waste shall be deposited above grade in a part of the waste disposal ground other than the actove area.

7 Liquid wastes shall not be deposited at a Class I waste disposal ground.

SCHEDULE B

WASTE DISPOSAL GROUND OPERATIONAL REQUIREMENTS

CLASS II

1 Solid waste shall be deposited in the active area.

2. Solid waste shall be compacted and covered with a layer of earth compacted to a thickness of at least 15 cm. (5.9 in.) at least once each month, or at more frequent intervals prescribed by the Department.

3 Upon termination of use of an active area in excess of 0.4 hectares (1 acre), or upon closure of the waste disposal ground, a final cover of earth compacted to a thickness of at least 0.6 m. (2 ft.) shall be applied to the surface of the active area and the area shall be so graded as to minimize the ponding of water on the surface.

4 The active area shall be enclosed with a fence at least 1.8 m. (6 ft.) in height, constructed in such a manner as to contain the solid waste within the active area.

5 Where the municipality has not provided a metallic waste compount, bulky metallic waste shall be deposited above grade in a part of the waste disposal ground other than the active area.

6 (1) Where liquid wastes are disposed of at a Class II waste disposal ground, a liquid waste facility shall be established within the waste disposal ground, at a location separate from the active area.

6 (2) The liquid waste facility shall include:

(i) an excavation to a depth not exceeding 1.5 m. (5 ft.)

(ii) a dyke, constructed to a height of 0.6 m. (2 ft.) around the excavation and

(iii) an unloading facility.

SCHEDULE C

WASTE DISPOSAL GROUND OPERATIONAL REQUIREMENTS

CLASS III

1 Solid waste shall be deposited in the active area.

2 At least once in the spring and once in the fall of each year or more frequently if required by the Department, a general cleanup shall be undertaken such that the solid waste is confined to the smallest practical area within the active area, and is covered with at least 15 cm. (5.9 in.) of earth.

3 Upon closure of the waste disposal ground, a final cover of earth compacted to a thickness of at least 0.6 m. (2 ft.) shall be applied to the surface of the active area and the area shall be so graded as to minimize the ponding of water on the surface.

4 The active area shall be enclosed with a fence at least 1.2 m (4 ft.) in height, constructed in such a manner as to contain the solid waste within the active area.

5 Where the municipality has not provided a metallic waste compound, bulky metallic waste shall be deposited above grade in a part of the waste disposal ground other than the active area.

6(1) Where liquid wastes are disposed of at a Class III waste disposal ground, a liquid waste facility shall be established within the waste disposal ground, at a location separate from the active area.

6(2) The liquid waste facility shall include:

(i) an excavation to a depth not exceeding 1.5 m. (5 ft.);

(ii) a dyke, constructed to a height of 0.6 m. (2 ft.) around the excavation; and

(iii) an unloading facility.

6(3) The liquid waste facility shall be enclosed by a fence at least 1.8 m (6 ft.) in height and the fence shall have a gate with a lock under the control of the operator in order to prevent access by persons not authorized by the operator.

6(4) The level of liquid waste in the excavation shall be so controlled as not to exceed the height of the base of the dyke.